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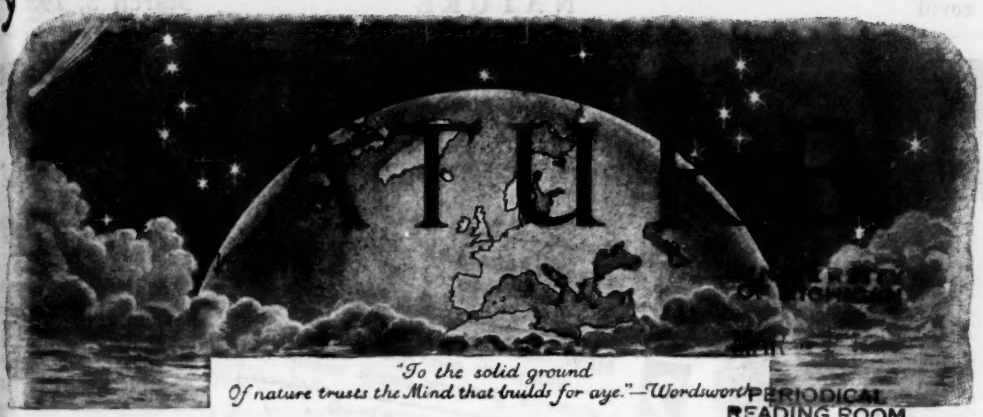

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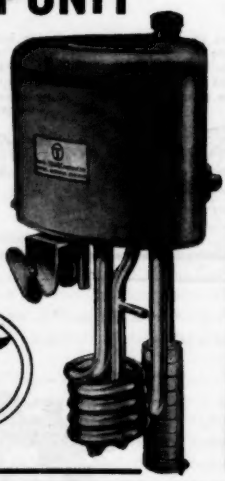

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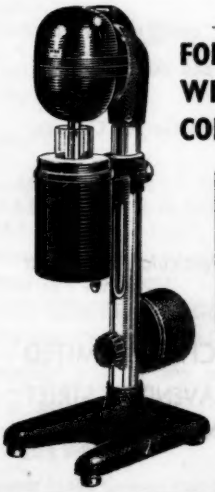

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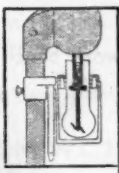

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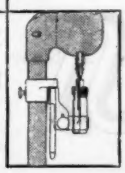

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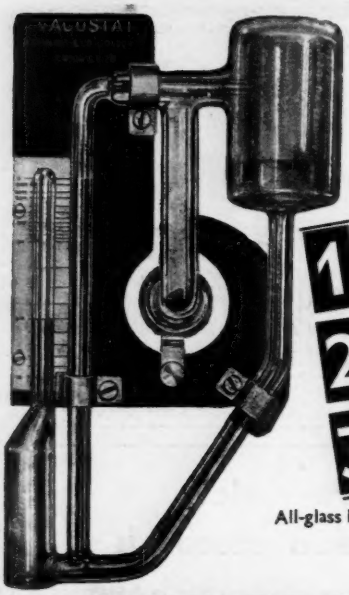

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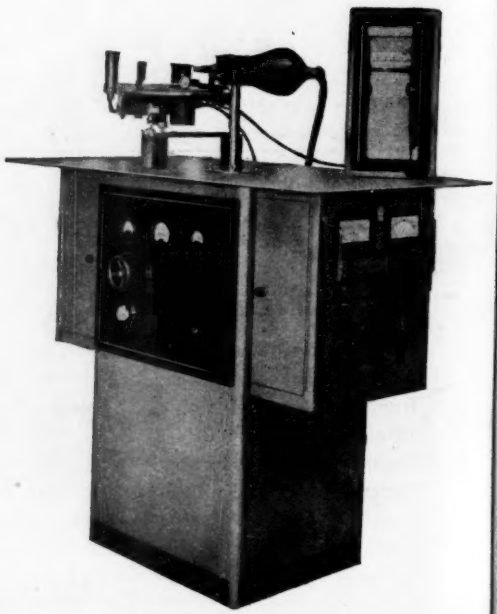

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AIR POLLUTION

THE results of a painstaking examination of the problem of air pollution, to which the attention of the public was acutely aroused by the lamentable consequences of the London fog of December 1950, appears in the recently issued report of the Committee on Air Pollution, presided over by Sir Hugh Beaver*. The published report is crowded from cover to cover with the results of detailed investigations of the manifold aspects of the problems encountered, and therein is set forth a series of recommendations, aptly defined as a clean air policy.

Legislation is called for to strengthen the law with regard to the abatement of atmospheric pollution. Quite a number of additional recommendations cover important aspects of public policy, which will command general acceptance; indeed, they are the logical development of efforts to improve the situation that have been prosecuted steadily for many years. Foremost among these more beneficent influences has been the general impact of research and engineering development on the design and use of combustion appliances in both the industrial and the domestic fields. The responsibility for atmospheric pollution is shown to fall about equally in these two spheres. The most difficult problem is the domestic one. The Committee considers that it is the cumulative effect of light smoke from a number of low chimneys that really matters, and the legislative provision recommended entails the institution of smokeless zones and smoke-control areas. A snag arises in the proposal that the Exchequer and the local authority are to contribute jointly towards the cost of converting domestic appliances in these areas. The installation of appliances of improved types for the main domestic space- and water-heating services is to be made compulsory in the case of new premises. Much higher penalties are to be invoked for the enforcement of the law of pollution abatement. The power-stations that burn pulverized fuel in any form beyond a rate of ten tons per hour are to instal efficient dust- and grit-arresting equipment. Cement kilns are apparently not to be subjected to this control, on the grounds of the greater technical difficulties involved, although it is well known by the public that some of the most pleasant beauty spots are plagued by this nuisance. It could have been wished that there had been a more incisive and courageous recommendation on this issue.

The question of sulphur pollution has been closely examined, and some of the possibilities indicated; but the value of a national policy of total gasification has been overlooked. It is true to say that more research effort in this direction is needed for a satisfactory process to be developed; but it is clear that the most effective means of removing sulphur, and indeed of recovering it in a useful form, is through gas purification. Though coke has many advantages as a means of domestic heating, it must be emphasized that the reserves of coking coal are limited. So far as coal is concerned, the larger reserves of less satisfactorily coking coals must be sooner or later brought into the picture.

Railway smoke comes in for strong condemnation, since more than one-seventh of the smoke discharged to the atmosphere comes from this source. The answer which is in line with the Committee's recommendations has been given by the proposals of the Transport Commission for the future development of British railways by the substitution of the steam locomotive by electrification and the most convenient form of diesel-engine traction. An unexpected situation arises in respect of motor-vehicle exhausts, which can be a serious menace. The present law is explicit and believed to be adequate; but the Committee could not find that it was, in fact, enforced.

There is a strong call for the use of smokeless fuels in the so-called 'black areas', and doubtless the development of this remedy will be followed as ways and means become available. To stimulate the use of gas and electricity, the removal of purchase tax on appliances is urged.

As to the precise measures to be taken to put into effect the very desirable requirements foreshadowed, the Government has already indicated by a recent announcement in the House of Commons that it has recognized that the key to the domestic smoke problem lies in the displacement of obsolescent equipment by more efficient types, and that the extension of smokeless zones must be made practicable by assistance in purchasing modern types from central or local government funds.

In the application of the many other recommendations of the Committee, it is hoped that there will not occur a possible danger of the confusion of the technical and administrative functions in putting the appropriate measures into action. This danger has long been a national failing, in regard to which technical opinion has not always been so forceful, or even active at all, in the right quarters as it should be. Initiative for certain technical measures is placed at the door of the British Standards Institution, when it should be more properly found in the board rooms and laboratories of the expert technical institutions, which must provide the pertinent bases for the specifications required.

The well-worn demand that stoking should be regarded as a skilled operation is repeated. One may only hope that the simile of water wearing away the stone will be here applicable.

Twelve appendixes of both technical value and public interest have been provided. Finally, a list of some hundred and thirty authorities that have been consulted are listed. There must have been numerous other individuals also consulted. The evidence is thus abundant that Sir Hugh Beaver and his Committee have laboured very hard in the public interest, and it is to be hoped that the response of the authorities concerned will be effective and prompt.

* Committee on Air Pollution. Report. Pp. 80. (Cmd. 9322. (London: H.M. Stationery Office, 1954.) 3s. net.

CHEMICAL CONSTITUTION

Chemical Constitution

An Introduction to the Theory of the Chemical Bond. By Prof. Dr. J. A. A. Ketelaar. Pp. viii+398. (Amsterdam and New York: Elsevier Publishing Company, Inc.; London: Cleaver-Hume Press, Ltd., 1953.) 40*s*.

CHEMISTRY has been revolutionized in the past thirty years by the development of quantum theory, and by the fresh insight the theory gave into problems of atomic and molecular structure. The new ideas spread rapidly under the influence of several notable monographs. In recent years, however, a growing rift has separated the theoreticians from chemists in general, largely because the more recent developments have not been adequately described in simple terms in book form; and the lack of text-books has also hindered the teaching of theoretical chemistry. Prof. J. A. A. Ketelaar's book is an attempt to fill this gap: it is described as "an introduction to the theory of the chemical bond" and is clearly intended for the general reader.

The book falls into five sections. First, an introductory section on the Periodic Table, the basic ideas of wave mechanics and the types of chemical bond; next, a section on ionic compounds treated from the classical point of view; next, a section on the covalent bond, beginning with the quantum mechanical treatment of covalency and the structures of simple molecules, and continuing with a discussion, in terms of resonance theory, of complex molecules and of such topics as conjugation, bond properties, chemical reactivity and colour; next, a short section on metals; and finally, a section on van der Waals forces and the hydrogen bond. There are bibliographies at the ends of sections, but few references.

The intention and general plan of the book are excellent; but unfortunately the execution leaves much to be desired. First, the more elementary sections are too condensed to be intelligible to a reader who needed them; this criticism applies to the whole of the first section, to the quantum mechanical treatment of covalency in the third section, and to the section on metals. The situation is made worse by the introduction of irrelevant complications (for example, pp. 9–10) and by an approach sufficiently mathematical to intimidate the uninitiated reader but totally inadequate as an introduction to the detailed mathematical theory. Secondly, the book is very badly constructed. Throughout the text there are numerous references to later sections; new ideas are introduced without explanation (for example, the table on p. 20, dipoles on p. 72, the Planck and Einstein relations on p. 107, the Bohr atom on p. 109, overlap on p. 149, bond character on pp. 175, 186); and when new ideas are introduced they are often not treated coherently in one place (for example, *s*-*p* hybridization is discussed in detail on pp. 153–54, but dsp^2 hybridization is mentioned without explanation on p. 173). Thirdly, the segregation of ionic and covalent compounds has its drawbacks; typical covalent compounds are discussed as though they were ionic in the second section (pp. 54, 55, 60), and the relation between ionic and covalent bonds is nowhere adequately discussed.

There are various small errors and omissions. For example, it is implied incorrectly on p. 152 that a linear combination of non-degenerate solutions of a wave equation is itself a solution; the inductive effect is wrongly described on p. 221; the explanation for the instability of vinyl alcohol on p. 222 is incorrect; and on p. 239 the author has overlooked recent work on Tschitschibabin's hydrocarbon.

The general impression is of a book written without adequate planning or integration and consequently too obscure for the uninitiated reader. A reader familiar with the field will find much to interest him although he may feel the lack of adequate references. Most of the references are to papers dealing in detail with advanced and irrelevant topics (for example, nuclear resonance, p. 199).

The book is very well produced and pleasantly free from misprints. The price is very reasonable.

M. J. S. Dewar

BIOCHEMISTRY FOR MEDICAL STUDENTS

Biochemistry

By Prof. Abraham Cantarow and Dr. Bernard Schepartz. Pp. xxv+848. (Philadelphia and London: W. B. Saunders Company, 1954.) 55*s*.

THIS is designed primarily as a text-book for medical students; but it is doubtful whether as such it will have much appeal in Britain. In most British universities, the departments of anatomy and physiology and biochemistry compete keenly for the student's time, and as things work out the medical student simply has not the time to deal with biochemistry in anything like the detail in which it is presented in this 800-page volume. If he attempts to do so he is likely to miss the wood for the trees and to develop a dislike for the subject. To take one example of this excessive detail and of lack of balance between one topic and another, nearly forty pages are devoted to what the authors term the metabolic "rugged individualism" of the amino-acids, whereas the absorption of fat is dismissed in a couple of pages.

More might have been said about how some of the important advances in biochemistry have been made. For example, in dealing with carbohydrate metabolism, some description might surely have been given of Claude Bernard's fundamental experiments leading to the discovery of glycogen and its role in blood-sugar regulation. Things like this make a subject interesting and they are often remembered by the student, and are worth remembering, when a great deal else has long been forgotten. Instead, the student is faced as early as p. 3 with about fifty divisions and sub-divisions of the carbohydrates, and on the next page he is further discouraged by finding the names and structures of all twelve D-hexoses where three or four would have sufficed. It is surprising that the authors have not adopted the elegant and more realistic method of Haworth for showing the structures of the carbohydrates. The Fischer formulæ when applied, as they are here, to disaccharides and even to polysaccharides may well strike the student as looking like radio wiring diagrams rather than structures of molecules.

At one point, where apparently the authors felt that the book needed a bit of light relief, there is a deplorable reproduction of a dog which is said to be afraid that the essential amino-acid tryptophan has been omitted from its dish of food. The book needs lightening in a much more substantial way than this if it is to appeal to medical students and give them

a lasting interest in biochemistry. Nowadays, writers of preclinical text-books ought surely to ask themselves all the time what can be left out rather than what can be put in, and whether the information can be presented to the student in a more vivid and more intelligible way by omitting details and unessential facts.

It should be emphasized that these criticisms apply mainly to the book as a text-book for medical students, though that, after all, is its declared purpose. As a book for science students with more time for biochemistry, it is in many ways excellent. The biochemical reactions and metabolic cycles are well set out in the figures, there are numerous cross-references, and important topics such as enzyme action and metabolic antagonism are discussed clearly and illustrated by helpful diagrams. There are a good many minor slips and misprints; but these are perhaps excusable in the first edition of a book containing so much detail. Science students and their teachers will find this a useful, original and up-to-date text-book. It should find a place beside its well-known companion volume, "Clinical Biochemistry", by Cantarow and Trumper, which incidentally managed to cover its ground without using any chemical formulæ more elaborate than that of carbonic acid.

D. C. HARRISON

A PHILOSOPHICAL TREASURE-HUNT

Treasury of Philosophy

Edited by Dagobert D. Runes. Pp. xxiv+1280. (New York: Philosophical Library, 1955.) 15 dollars.

THIS volume is another of the huge compilations so much in favour in the United States. It contains extracts, prefaced by brief introductions, from the works of nearly four hundred writers; they range from Anaximander to Sartre, from Chuang Chu to Johann Comenius. There are excerpts from the works of Oriental philosophers and theologians, medieval Hebrew writers and the Arab commentators on Aristotle. Some of this material is, we are told, here made available in English for the first time, though the translators are frequently not named. It is valuable to have some indication of the views of the less well known of these thinkers. The editor observes with some justice that American philosophers are too much neglected in European surveys of the subject, and accordingly he tries to remedy this deficiency. Unfortunately, he has included the work of unimportant people like Henry Ward Beecher and Amos Alcott, the father of Louisa May, who ramble on in the folksy 'philosophizing' vein of Will Rogers. It is very surprising that no reference whatever is made to what is probably the most remarkable American contribution to philosophy, the "Treatise on Language" by Alexander Bryan Johnson, published in 1836.

The book as a whole is vitiated by two serious deficiencies. There is no principle of selection; in fact, Dr. Runes admits that he has no clearer conception of philosophy than that it is "the search for the undefinable", and he asserts that the only thing common to the contributors is that they have at some time "sat down to meditate upon the wondrous themata that came to their minds in uncharted realms". It is scarcely surprising that such a wide-meshed net has failed to keep out writers like Walt Whitman, Charles Lamb and Maurice Maeterlinck. The second shortcoming is a consequence of the huge scale of the anthology, which is so ambitious as to be self-defeating. The extracts are perforce so brief that many are scarcely intelligible. For this reason, considerations of price apart, the book cannot be recommended as an introduction to the subject, while anyone with some acquaintance with philosophy will probably find reading it a depressing experience; it is like walking around a dissecting-room scattered with the disjointed members of one's friends.

C. K. GRANT

A TEXT-BOOK OF EMBRYOLOGY

Developmental Anatomy

A Textbook and Laboratory Manual of Embryology. By Dr. Leslie Brainerd Arey. Sixth edition. Pp. xi+680. (Philadelphia and London: W. B. Saunders Company, 1954.) 47*s.* 6*d.*

THE present volume has been extensively revised in the light of recent developments in embryology. In addition, the material in the book has also been rearranged so that there are now twenty-eight chapters instead of twenty-three. The aim of the author has been to subdivide larger chapters of earlier editions of the book "into shorter and friendlier units". In this aim he has succeeded. A consistent policy throughout the book has been to use larger type for "basic information" and smaller type for so-called "supplementary information". It is debatable whether this approach is desirable in a text-book which is essentially for students. The average student is in doubt as to whether or not to leave out the supplementary material.

The book is divided into three main parts.

Part 1 deals with general development and includes chapters on fundamental concepts, reproductive physiology, placentation and experimental embryology and teratology. Part 2 is essentially devoted to organogeny, and Part 3 is in the form of a laboratory manual.

The experimental approach to the pertinent developmental mechanics is admirably dealt with as a separate entity in a chapter on experimental embryology. Details concerning developmental mechanics of different organs are also discussed in a brief summary under the heading of "Causal Relations" in the appropriate chapter. In most instances this discussion is useful and valuable, but in others it is much too brief.

Part 3 of the book is in the form of a laboratory manual and deals with the embryology of the chick in the earlier stages of development and also with the anatomy of the 10-mm. pig embryo. The embryology of the chick is undoubtedly of value in the details which it gives to the student of biology; for the medical student it is much too detailed. One would have preferred to have had the anatomy of the 5- and 10-mm. human embryos given, instead of that of the pig. This section and, indeed, other chapters in the book should have photographs of sections of embryos rather than semi-schematic drawings.

The revision of the book has been carefully carried out. The author must be congratulated in producing a readable book of reasonable dimensions in a subject which is rapidly expanding. The publishers must also be congratulated on the excellence of the reproduction and the general format of the book.

W. J. HAMILTON

SCIENTIFIC PROGRAMME OF THE INTERNATIONAL GEOPHYSICAL YEAR 1957–58

By Prof. SYDNEY CHAPMAN, F.R.S.

Introduction

THE International Geophysical Year is the name associated with a forthcoming large-scale scientific study of the earth, now being planned and prepared. It will in our generation be the culmination of a long series of such efforts extending from the distant past. In the third century B.C., the Alexandrian natural philosopher Eratosthenes first measured the size of our globe. In A.D. 1600 William Gilbert's treatise on magnetism and electricity announced that the earth itself is a great magnet. Halley's undergraduate astronomical excursion to St. Helena in 1676 to observe the southern stars helped to lead him ten years later to produce the first extensive meteorological chart, of the trade winds. His magnetic voyages in the north and south Atlantic during 1698–1700 bore fruit in 1700 and 1701 by his publication of the first global magnetic charts. In the eighteenth century the French geodesists re-measured the globe by observations in Peru. Early in the nineteenth century Maury applied his studies of the winds to navigation by sailing vessels, and initiated world co-operation in maritime meteorology. Since the second half of that century, international scientific co-operation, particularly in geophysics and astronomy, has developed apace. The first and second International Polar Years of 1882–83 and 1932–33 were organized mainly for arctic observations of magnetism, meteorology and the aurora (the Second Polar Year only, not both First and Second as stated in *Nature* of January 8, p. 55, fell near sunspot minimum); in 1902–3 there was a concentration of scientific effort, on a smaller scale, in the Antarctic. The International Geophysical Year will be a fit successor to these earlier enterprises, far surpassing them in scope and intensity.

The Arctic, the Antarctic and the tropical belt, together with the meridians 70°–80° W., 10° E., and 140° E., will for the Geophysical Year programme as a whole be regions of specially intensive and complete investigation. The meteorologists will add many other special regions for their part of the programme. The effort to be devoted to the Antarctic will be an outstanding feature of the enterprise; no less than twenty-one antarctic stations are planned, which should lead to a major advance in our knowledge of a part of the earth of which in some ways we know less than we do of the moon.

Meteorology

As in the two Polar Years, meteorology will be one of the main branches of the investigation. The range of observation will be global, not only or mainly arctic. In the first Polar Year the observations were made at the earth's surface; in the second Polar Year the atmosphere was explored in height as well as on the surface: the results were signalled by radio to the ground, thus obviating the need for recovering instrumental records from balloons the landfall of which could not be predicted. A major aim during 1957–58 will be to extend this exploration in height over a much greater part of the globe than hitherto, and to higher levels than before—especially in the tropics, where the troposphere is more than twice as deep (there approaching 20 km.) as it is at the poles (about 8 km.). At the standard meteorological stations the plan is to measure the height distribution of air temperature twice daily, and of wind four times daily, up to 20 km., and wherever possible—especially on the Regular World Days (three per month)—up to 30 km.; on these days, when observations are to be specially intensive and widespread, the temperature observations are to be made four times daily.

The main objective will be to study the general circulation of the atmosphere, and the interchange of heat, momentum, angular momentum and entropy between the different parts of the globe. Hence the winds will be specially observed, by radio echoes from balloon-borne reflectors, and also by cloud observations from land and from ships at sea. The meteorological influence of the large-scale topography of the globe—the continents and oceans, and the great mountain chains and massifs—will be investigated. The familiar surface measurements of precipitation, and of air and surface (soil or water) temperatures, will be made more extensively, especially over the oceans; many small oceanic islands will be centres of scientific work of these and other kinds.

Besides the above fundamental measurements, the programme includes more widespread and extensive study of the atmospheric height distribution of ozone and water vapour; of solar and terrestrial radiation (including the albedo of the earth, as indicated by earth radiation reflected from the dark face of the moon); of the high 'mother of pearl' clouds and the far higher luminous night clouds; of thunderstorm regions over land and sea, by radio records of atmospherics; and of the chemical composition of the air, for example, its oxygen and carbon dioxide content in the Antarctic. Rockets will extend the exploration of the atmosphere far above the heights attainable by meteorological balloons.

Under the guidance of the World Meteorological Organization, and with the co-operation of the International Association of Meteorology, instruments and methods of observation and publication will be standardized, and plans made for the handling and discussion of the immense mass of observations thus to be collected. The oceanographic programme of Geophysical Year observation will be an important supplement to the meteorological programme.

Geomagnetism

The chief geomagnetic problems to be solved are those relating to magnetic storms—long studied, but never with an adequate network of observatories. During 1957–58 the network of regular observatories will be enhanced, and be valuably strengthened by magnetic recorders installed at many ionospheric (and perhaps also cosmic ray) stations, for their own purpose of gaining early awareness of magnetic disturbance. The methods and instruments will be similar, in the main, to those used during 1932–33;

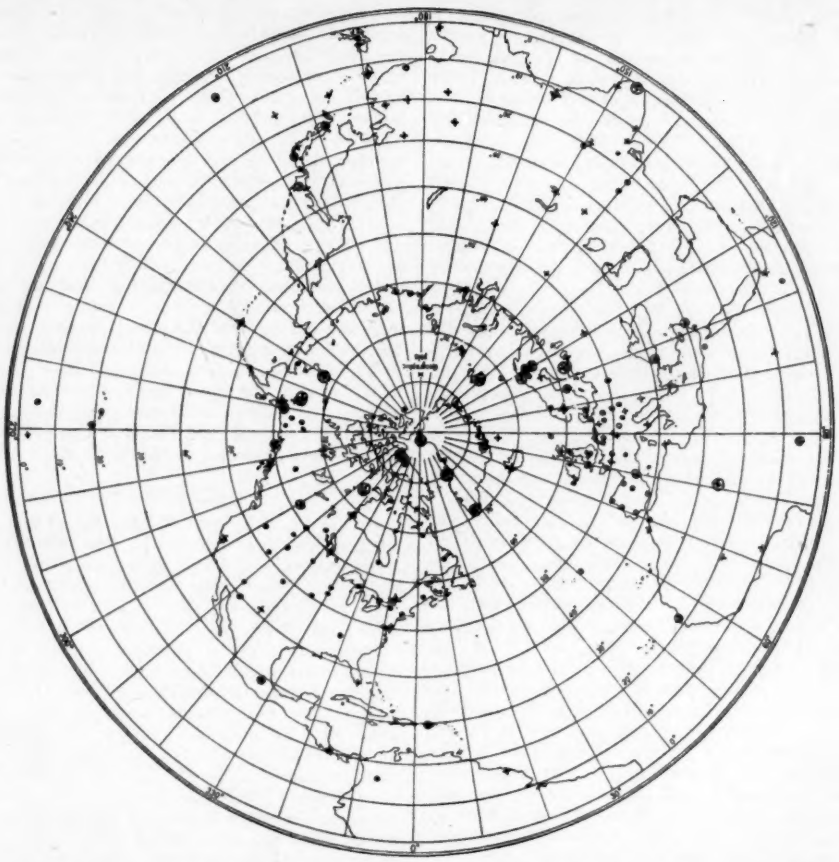

Fig. 1. Observation stations in the northern hemisphere for the International Geophysical Year: auroral stations, ●; ionospheric stations, +; magnetic observatories, ○. The southern hemisphere will have fewer stations. Geomagnetic co-ordinates

but at some stations in or near the auroral zone the space gradients of the magnetic field will be measured, by setting up two satellite sets of recorders some miles distant, one to the north or south, the other to the east or west; these satellite stations, near enough to be managed by the staff at the main station, will, it is hoped, contribute materially to our knowledge of the intense systems of electric currents in the arctic ionosphere. These currents will also be explored in more detail, and closer at hand, though only for a few brief intervals of time, by magnetometers carried into or near them by rockets launched in high latitudes during magnetic storms.

Special care will be taken to avoid loss of record (such as occurred all too often in the past) during any very great magnetic storms that may befall during 1957–58.

The concentration of daytime electric current over or near the magnetic equator will be more fully observed by an increased number of tropical magnetic observatories.

Improved and more extensive recording of magnetic pulsations, and also of earth currents, will be further important features of this part of the programme. As a contribution to the correlation of geomagnetic with other data, it is expected that indices of geomagnetic activity will be made available for each quarter-hour throughout the Geophysical Year, instead of, as now, for each three-hour interval.

The Aurora

The International Geophysical Year is too brief an interval to afford much improvement in the long-range statistics of auroral frequency; but it should mark a great advance in the observation of the many auroræ that may be expected to occur during the Year. In the regions where auroræ are often visible, at geomagnetic latitudes 60° and more, there will be a network of auroral stations equipped with automatic cameras that will photograph the whole sky every five minutes throughout each night; these will afford a synoptic view of the terrestrial extent and of the changes of auroræ never hitherto realizable. (Incidentally, this may also provide valuable data concerning cloud cover.) At some of these stations there will be automatic scanning spectrographs giving a succession of spectra of the auroral light in the vertical meridian plane, over nearly the whole arc from horizon to zenith to horizon. In rather lower geomagnetic latitudes, where auroræ are less

often visible, there will be a few stations similarly equipped; and there will be networks of visual observers, including some on sea as well as land, some equipped with angle-measuring devices, and with filters to isolate different spectral bands of the auroral light (thus cutting down the background sky light, especially during twilight and moonlight); some stations may have colorimeters designed to record the nature of the auroral light less elaborately than by spectrograph. Air pilots will take part in such visual observation, with special benefit when the sky is overcast. It is hoped that the network of careful visual observation will be extended into low latitudes, where the work should be much aided by the world system of warning of expected magnetic disturbance; professional, volunteer and other aid from meteorological and other organizations will especially be sought in these regions of lower latitude. A watch will be kept for the simultaneity of appearance of auroræ at the two ends, northern and southern, of a line or lines of geomagnetic force, or at pairs of stations in nearly the same geomagnetic longitude, and nearly equal northern and southern geomagnetic latitudes. The possibility of such observations is determined mainly by the availability of sites for fixed stations in high southern geomagnetic latitudes. For example, Macquarie Island (54·5° S., 159·0° E. geographic; 61·1° S., 243·1° E. geomagnetic) could be paired with an Alaskan station to the south-west of College, Alaska; and Heard Island (53·0° S., 73·4° E.; 61·2° S., 129·9° E.) could be paired with a north Siberian station. Means of intercommunication between such pairs of stations would be useful though not essential.

Some radio observatories will explore the auroral regions by short-wave beams echoed back to the station by suitably placed auroræ; by this means auroræ can be detected and located from a considerable distance, independent of cloud cover, and by day as well as by night. Any radio waves emitted from the aurora itself will also be registered.

Measurement of the increased scintillation and absorption of the radiation received from radio stars, when it passes through an auroral region, will be another and novel means of study of the enhanced ionospheric turbulence and ionospheric drifts associated with auroræ.

Special spectrographic studies will be made of the Doppler effect in the light of the hydrogen atoms which rush downward along the auroral rays and are scattered in all directions near the base of the rays. These or accompanying electrons will be detected and counted by ionization chambers borne by rockets launched from balloons.

The Airglow and the Zodiacal Light

All over the globe the upper atmosphere emits light, the airglow, which in general is too faint to be visible to the eye or to be photographed directly with short exposure; though sometimes patchy, it does not have the definite forms generally shown by the aurora. It is enhanced at twilight, and is observable also by day from rockets high above the atmospheric layers where the beam of solar radiation is scattered to give the general sky light. Its geographical distribution, changing with time of day and with season, will be investigated during the Geophysical Year, by means of scanning photoelectric photometers sensitive to four or more spectral bands of the radiation. These instruments, which automatically survey the entire sky each half-hour, will be disposed at intervals along a meridian chain, beginning at Thule, Greenland, and, crossing the auroral zone, extending through Canada, the United States and Mexico; others will be in Alaska, Hawaii and the Belgian Congo. Less complicated photometers, recording or visual, will be placed at further stations; the observations will necessarily measure, besides the intensity of the airglow, that of the auroral light, when present, and (in low latitudes) the zodiacal light. All these photometers will be carefully calibrated by astronomical methods or by the use of fluorescent surfaces activated by radioactive material of long life.

In addition, spectrographic and interferometric studies of the airglow will be made at a few special stations, and some high-level spectral observations will be made from rockets. Such studies will deal in detail with the various components of the spectrum of the airglow, its green and red atomic oxygen lines, the oxygen (and possibly nitrogen) bands, the yellow doublet of atomic sodium, and the strong infra-red and other radiations of the hydroxyl molecule OH.

Cosmic Rays

As for the airglow, so also for cosmic rays, the Geophysical Year will be the first occasion on which a prolonged simultaneous standardized scheme of world-wide observation will be operated. Two main types of instrument will be used in this survey, one a counter telescope to record rays of relatively high energy, the other a neutron monitor for the low-energy part of the cosmic-ray spectrum. The ionization-chamber counters already in operation at several stations should continue also throughout 1957–58. Detailed indications of the construction and operation of the two standard types of instrument will be made available in good time by the Geophysical Year Sub-Commission of the International Union of Pure and Applied Physics. It is hoped that the synoptic network will include sixty or more stations disposed in the special Geophysical Year areas (zones and meridians) and elsewhere; many of the instruments may be located at meteorological, magnetic or ionospheric stations.

As in other branches of the Geophysical Year work, plans will be prepared for standardized forms of recording the synoptic observations, for interchange of observations between stations, and for publication.

Additional special cosmic-ray investigations are planned, including moving photographic-emulsion records of the heavy-particle component, and high-altitude observations to determine the momentum spectrum, from mountain stations, aircraft, balloons and rockets. But the main emphasis of the cosmic-ray programme will be on the investigation of geomagnetic, aeronomic and solar problems to which cosmic-ray observations may be able to make a distinctive, perhaps unique, contribution.

The value of these observations will be greatly enhanced by the unprecedented array of solar and geophysical data available during the Geophysical Year.

Solar Observations

The Geophysical Year will be at or near a sunspot maximum which is expected to be of considerable but not exceptional intensity. Because so many geophysical phenomena are related to solar activity, it is hoped that this will be continuously observed in the several different ways now possible. To this end,

the observing hours at solar observatories will be extended in order to give an overlap of the periods of observation at stations in different longitudes, so that spells of cloudy weather at one or other station may not break the continuity of record. The long-continued records of sunspot numbers, their positions and areas, of prominences and faculæ, will be supplemented by spectroscopic, spectrographic and photographic observations of solar flares, by spectrophotometric observations of the inner corona, and by records of solar radio emissions and their polarization, at a series of wave-lengths. Interferometric studies of the location of the radio sources will be made. Further, rocket spectra of sunlight at successive high altitudes will be photographed at intervals throughout the Geophysical Year.

Some solar observatories will equip themselves with recorders of atmospherics, which can give visual indication or audible warning of the beginning of solar flares, because of the improved propagation at such times. This will enable special observations to be made outside the normal 'solar patrol' periods.

The distribution of the line-of-sight component of the magnetic field of the sun will be mapped over the solar disk two or three times a day, by the Babcock method, at Mount Wilson and perhaps also at other solar observatories.

The solar observations during the Geophysical Year will be of cardinal importance to the scheme of world notification of Alerts and Special World Intervals, at times when magnetic, auroral, ionospheric and perhaps also cosmic-ray disturbances may be expected. Solar data as complete as possible will be vital for the detailed study of the sun's influence on magnetic, auroral, ionospheric, cosmic ray, and perhaps other data to be obtained during the Geophysical Year.

Ionospheric Investigations

The pioneer arctic ionospheric investigations made during the second Polar Year were the most important extension of the programme of that enterprise, as compared with the programme of the first Polar Year. The fledgling of that epoch is now grown to be a major member of the Geophysical Year programme. More than a hundred stations for the exploration of the ionospheric layers overhead, by vertical beams of pulsed radiation, are expected to be in operation during the Geophysical Year; their distribution will in large part conform to the general plan of concentration along particular zones and meridians; but the considerable influence exerted on the ionosphere by the geomagnetic field will be taken into account by siting some stations with special reference to geomagnetic latitude, that is, to latitude relative to the axis of the main (dipole) component of the earth's field, with its north geomagnetic pole at 78·6° N., 70·1° W. (1945).

This now standard method of ionospheric investigation, from fixed stations and also from aircraft, will enhance our knowledge of the complex and changing structure and disturbances of the ionosphere, from the equatorial to the auroral regions. In addition, many special studies will be made, at fewer stations: of tropospheric propagation, of absorption, of ionospheric drift, of both back and forward scatter, of radio star scintillation, of atmospherics, of auroral and solar radio noise, of radio echoes from meteors and auroræ. There will also be direct exploration of the ionosphere, *in situ*, by rockets. The fulfilment of these plans should gather a rich harvest of aeronomic observations for study in association with solar, magnetic, auroral and airglow data. The ionospheric prediction stations in association with the solar observatories will play a vital part in the plan for World Alerts and Special World Intervals.

Longitudes and Latitudes

In the past there have been two world-wide determinations of the longitude differences between major astronomical observatories; the later one was in 1933. During the Geophysical Year, both the longitudes and latitudes, and the variations of these quantities, will be determined. This will lead to improved measurement of time, more precise determination of the irregularities of the earth's rotation, and corrections to star catalogues. The participating observatories will be those associated with the Bureau International de l'Heure, and, it is hoped, others newly organized and equipped, in areas where there are great gaps, especially near the equator and in the southern hemisphere. New types of fundamental instruments will be used.

In addition, a new method will be applied to determine the mutual relation of the geodetic networks covering the continents, by frequent photography of the moon against the background of stars, from about twenty well-distributed observatories; by this technique it is expected that the uncertainty of the extent of the oceanic gaps separating the networks will be reduced from 200–300 ft. to about 100 ft.

The availability of the great store of meteorological and ionospheric data to be obtained during 1957–58 will materially assist these undertakings.

Glaciology

The extent, character and behaviour of glaciers and snow cover will be measured in many parts of the world; this simultaneous survey will be far more geographically comprehensive than any made hitherto, and will be of great importance to meteorology and climatology. Apart from direct measurements at or from fixed stations, air reconnaissance will be used. Fixed survey points will be set up on selected glaciers in order that changes may be adequately determined by future comparison with later observations.

One great objective is to investigate the ice morphology and measure the total ice content of Antarctica. In this plan the co-operation of American, Australian, French and perhaps other nations is hoped for. It is anticipated that, with the aid of special aircraft, widespread seismic surveys will be made to determine the thickness of ice over the whole continent, and to settle the geography of the coast under the ice cover. This survey has special importance for the long-term climatological prediction of sea-level changes. The limits of permanent ice—a matter of present interest and valuable for comparison with future surveys—should be charted with considerable accuracy.

Oceanography

Many great problems of the oceans, especially in the southern hemisphere, await solution. Several ocean survey vessels belonging to the United States, Britain, West Germany and other nations will work on a co-ordinated plan during 1957–58. The water circulation, sediments and crustal structure will be

studied along two meridians, and the measurements will include water velocities determined electromagnetically, and the heat exchange between sea and air, as well as the customary temperature, salinity and other standard measurements. About forty new stations will be set up, equipped with tide gauges and non-tidal long-wave recorders, on many islands and on some continental coasts. The shifting boundary between temperate and arctic waters, and the warming of the Arctic, will be studied. Continuous echo sounding, registration of magnetic intensity by towed instruments, collection of plankton by towed nets, radiocarbon sampling of the deeper waters, measurement of temperature gradients in sediments, collection of long sediment cores, and seismic reflexion observations will be among the activities of some of the oceanographical ships; these will also be available, so far as possible, as moving 'stations' for other types of geophysical observation.

Seismic and Gravity Measurements

The Geophysical Year will provide opportunity for seismic recording and gravity measurements to be made at many antarctic and island sites not ordinarily accessible or available, and it is expected that many expeditions will include such work in their programme.

The Rocket Programme

Rockets provide the most important new technical feature that distinguishes the Geophysical Year from the second Polar Year. They will enable the atmosphere to be explored over a much increased range of height in various ways, and may considerably extend our understanding of upper atmospheric processes and our knowledge of solar phenomena that affect the earth. The technical advances that are involved concern not only the rockets themselves, but also the measuring devices they carry. The measurement of atmospheric properties by instruments travelling at high speed presents difficult problems. During the past decade American scientists have made remarkable progress towards their solution, and the tide of invention in this field continues to flow strongly.

In most of the upper-atmospheric rocket researches thus far made, large and very expensive rockets have been used, launched from a desert site in New Mexico, with costly ground installations. The smaller rockets of this type can be, and have been, launched also from specially fitted ships. Recently, however, a much cheaper method of rocket exploration has been developed by Van Allen and his colleagues. The rocket is carried up to a considerable height by a large balloon, and launched at a predetermined pressure-level. The launching heights have ranged up to 27 km., and the heights attained have at times exceeded 100 km. The load that can be carried up to about 100 km. is 15 kgm., which permits a wide variety of researches, such as those on cosmic rays, ozone, pressure, density and temperature, the solar spectrum, the sky brightness and airglow, geomagnetism, auroral particles, and ionospheric physics. The combined rocket–balloon system is called a 'rockoon'. Investigations are in progress into the vertical launching of rockets from aircraft, and if successful may contribute to the Geophysical Year programme.

The American National Committee for the Geophysical Year plans to fire approximately thirty-six large rockets ('Aerobees') and about a hundred rockoons, distributed throughout the period, and also geographically, from the Arctic to the Antarctic. Many of the above researches, if not all, will be included in the programme. The French National Committee plans to launch twelve of the large French rockets ('Véronique') from the Sahara, in pairs, at intervals; their instruments are expected to measure pressure and density, ionization, solar radiations, and particle masses (by mass-spectrograph). It is greatly hoped that other nations will also contribute to the rocket programme.

Problems of Organization and Finance

The achievement of the Geophysical Year will depend on the effort and funds devoted to it by the different participating nations. Naturally, their contributions will be unequal in magnitude and kind; help will be afforded by some nations to other nation-partners in the enterprise, by provision of instruments, training of observers, reduction of observations and in other ways. The unprecedented volume of observations that will accrue will present problems of collection and discussion for which detailed plans are not yet made. Many important points as to methods and recording of observations, and standardization and calibration of instruments, await settlement. Some important nations have still not associated themselves with the Geophysical Year. Thus there remains much scope for effort and thought in order to render the enterprise as successful as possible. But the stage already reached, more than two years before the Year begins, is good ground for confidence that the scheme will far surpass every previous co-operative scientific effort of its kind, and that it will lead to notable advances in knowledge of importance and interest to mankind. When the Geophysical Year ends, the level of activity in geophysical observation will necessarily drop rapidly and considerably; but past experience indicates that the subsequent level will still mark a distinct rise above the present level; thus it will afford a higher stage from which at some later epoch another International Geophysical Year can mount to yet greater heights and intensity.

A PATTERN FOR INDUSTRIAL RESEARCH

In 1953, seven senior executives of the United Steel Companies, Ltd., were invited to lecture to engineering undergraduates in the University of Cambridge on various aspects of industrial management. The lectures have now been presented in book form*, and among them is a valuable contribution to contemporary thinking about the organization and application of scientific research in industry by Dr. J. H. Chesters, assistant director of research to the Company.

The research worker in industry spends a good deal of time on development work that adds little to scientific knowledge; on the other hand, his best achievements are often based on fundamental data which he himself has collected or been able to appreciate and apply.

* Industrial Management: a Course of Lectures given at Cambridge University for the Faculty Board of Engineering. Pp. 124. (Sheffield: United Steel Companies, Ltd., 1954.)

The usefulness of a research department depends primarily on the originality, initiative and effort of the staff; but the framework within which research workers function greatly influences the results.

The research department may vary from one man to giant organizations, such as Bell Telephones, which must be considered as plants in themselves and indeed, in the United States, are registered as separate companies. In Great Britain there is wide variation (0·4–5·3 per cent) in the research and development costs expressed as a percentage of turnover in different industrial groups. In the scientific instrument and light electrical engineering industries the figure is more than 5 per cent, in chemicals 2·4 per cent, whereas for the ferrous industry and for food, drink and tobacco it is only 0·4 per cent. In general, the older the industry the less is its present investment in research. One reason for this is that iron and glass can be made, and indeed have been made, without any precise scientific knowledge; but radio sets would not even have been thought of unless a great deal of fundamental research had been done.

A research unit consisting of a university graduate backed up by two assistants can be run for an average expenditure of £3,000 per annum. In the United States, industrial research activities account for less than a half per cent of the cost of goods and services of the undertaking.

Research in the United Steel Companies costs approximately a half per cent of all sales. There is a total staff of almost two hundred, who study all the major aspects of iron- and steel-making in metallurgy, engineering, physics, chemistry, mathematics and geology.

The possession of a first- or second-class honours degree is by no means the sole criterion in the choice of an industrial research worker. The ability to work in a team has long been recognized as equally vital, the isolated research worker being now something of a curiosity. The old vertical-type team consisted of a section head with his senior and junior assistants. The new type team—which is of a horizontal character and requires the fullest co-operation between different section leaders and their staffs—calls for an even higher conception of team-work.

The efficient use of specialists demands that they be supported by other workers who do not require to be as highly qualified. In the United Steel Companies about a hundred university graduates and men with equivalent qualifications are backed up by more than a hundred other members of staff, many of whom left school when they were sixteen, but have since acquired considerable skill in some particular field of activity. The old idea of 'lab. boys', who often finished in blind-alley jobs, is rapidly dying out.

The senior staff, too, are encouraged to continue their studies and to join appropriate scientific or technical societies. By so doing they not only increase their background of knowledge, but also get the opportunity of 'sparking' their minds on those of workers in other fields.

Considerable experience now exists on the building of research departments, and such elementary mistakes as putting dirty and clean work adjacent to one another, or heavy machinery near equipment requiring freedom from vibration, rarely occur. Where a new laboratory replaces an old one certain new problems arise, notably the clash between the desire to have a smart modern laboratory and to do work that can be far more efficiently carried out if a certain amount of mess is permissible. The best, though still imperfect, answer would seem to be the segregation of 'dirty' activities in either a separate block or outbuilding.

Another risk with new and impressive laboratories is that the worker is less inclined to use the 'string and sealing wax' technique. Unless encouragement is given to start with rough equipment there is a tendency for the research man not to start his experiments at all until he has designed what he considers to be a good-looking piece of equipment. Far quicker results would be obtained and much money saved if at least early work is done with a crude assembly, and this only converted to an engineering job where accuracy or long-term use demands.

The jobs tackled in an industrial research department can be conveniently divided into those which arise internally and those arising from external demand. The latter may come direct from the plants or arise from long-term policy laid down by high-level management or the numerous technical committees that form so valuable a part of large-scale industry.

External demand is not, of course, limited to the works; it includes the demand by customers for materials to meet more arduous service conditions or for the solution to a problem that is difficult to solve by engineering means. An example of the latter was the joining of austenitic and ferritic tubes, the different coefficients of expansion of which would affect the tightness of a bolted joint, or the stresses in a plain butt weld in conditions of fluctuating temperature. An appreciation of the desirable characteristics of such a joint in service and the potentialities of an extrusion press in producing the necessary conditions for making a pressure weld enabled a tubular transition piece to be evolved which consisted of a ferritic tube gradually tapering to zero thickness inside an austenitic tube increasing at the same rate from zero to the full tube thickness.

At least a third of the solution to a problem lies in stating it correctly; research work often suffers because the true nature of the problem is not appreciated before the work began. A close examination at the start may even show that the problem does not really exist, is trivial, or such that a solution would yield little benefit. In the United Steel Companies all major items of work in the research department are covered by means of investigation sheets, which state in a few paragraphs the nature of the problem, the method by which it is to be tackled, and a list of the plants expected to benefit if a useful conclusion is reached.

Most research departments carry more investigations than they are really capable of handling. This leads to double dissatisfaction, the user being depressed because his problem gets little attention, and the research worker annoyed because he is perpetually asked to report on investigations on which he has done no work for some time. A rough rule is that the number of investigations in a section should not exceed that of the staff.

It is a tradition with research workers that they commence an investigation by searching the literature. The industrial worker rarely has time to do so at all fully, but can be greatly aided by an information section which keeps him continually informed of developments in his field, and can cover a far wider range of literature than he can ever hope to do by his own specialized reading.

Speed is frequently vital in industrial research. There are occasions when, to be of value, information must be provided within a day. If the research organization is sufficiently flexible, such demands can sometimes be met. The research department was once asked at 9 a.m. whether the collapse of a new steel furnace roof was due to poor brick quality or to operating procedure. The roof had to be replaced that night, and any answer after 5 p.m. could not affect policy for the next furnace campaign. By switching all the staff of the refractories section to the problem, all the standard properties of the suspect-bricks were determined and a report issued over the telephone at 5 o'clock to the effect that there was nothing wrong with them and that the same quality should therefore be employed in the new furnace. The subsequent behaviour of the furnace showed this to be the right decision.

The object of research should be the provision of genuinely new information in which is included quantitative research hitherto only understood qualitatively. The results obtained may at first prove unpalatable, because they conflict with previous assumptions.

From the practical point of view, a result opposite to that anticipated frequently proves to be of value. As an example may be cited war-time troubles with induction furnace linings, due to the loss of the previously used Austrian and Greek magnesite. At the time and on an apparently sound theoretical basis, it was believed that the ultimate test for induction furnace lining materials was their ability to withstand high temperatures without shrinkage—shrinkage cracks being thought to lead to metal penetration and a consequent strike to the high-voltage water-cooled coil. This hypothesis was overthrown by the results of laboratory tests on a wide range of linings, which showed that the satisfactory ones frequently had a high shrinkage when heated to 1,600° C., while those that failed mostly showed a low shrinkage.

A large proportion of the more important developments arise from accidental observations. This was seen in the metallurgical field by work on boron, which was added among other materials to 0·5 per cent molybdenum steel to prevent the cracking of steam pipes. It was noted that the boron–molybdenum steel had twice the proof stress of mild steel and yet possessed similar weldability. Realizing that such a steel would be of great value in reducing the weight of engines and structures, its properties were thoroughly investigated and this led to a valuable contribution in aircraft gas turbine design, and the provision of light-weight structures generally.

Assessment of a job frequently indicates that an efficient attack requires the cutting across of section boundaries. Development of a new-type furnace, for example, may demand co-operation with those concerned with such primary aspects as flow pattern and combustion on one hand, and design and development engineers on the other, the latter putting an engineering interpretation on what may have started as a rough sketch.

It is often assumed that such co-operation should be easy with scientific workers, since they are solely concerned with the discovery of truth. In actual fact, they are just as liable to be upset if credit goes elsewhere for work they have done. The techniques for ensuring that credit in team-work is given where it is due are still very much in the evolutionary stage. One method is the symposium, in which the various contributors are given a place that is at least roughly related both qualitatively and quantitatively to their own contribution to the work.

Industrial research departments can be classed into those which like to keep everything secret and those which are willing to talk of almost all the work they have in hand. It is the latter approach which will ultimately survive, since the willingness to give generously of information without guarantee of return seems essential to healthy development.

Good reports of research are essential, since they are the foundation of future work; the research worker must be prepared to finish his report with clear and concise conclusions and recommendations. Most young research workers, and some older ones, object to writing a report until the work has reached a stage where they feel they can give a full answer to the problem. The result is that the practical man is starved of information for long periods, while the research worker frequently gets so involved in his deliberations that he ceases to see the problem at all clearly. The right answer to this difficulty would appear to be the issue of interim reports. Sometimes it is desirable to follow the series with a summary report in which the chaff can conveniently be separated from the wheat. Moreover, if the research worker is incapable of putting his discoveries into simple language, it may well be because he does not really understand what he has found out.

On costs the research director should be given a reasonably free hand. "How do you *know* that research really pays?" is by no means an easy question to answer, particularly where research is mainly concerned with the improvement of a product. Where it deals equally with production processes, however, it is frequently possible to show that the savings associated with quite a small number of investigations are of such a high order as to leave no doubt whatever regarding the overall economics of the research department.

The research director's attitude to patents will be greatly influenced by the type of work done in his department, and also the general policy of the company. Some firms publish little, but take out many patents; others have few patents but publish almost everything. It is often doubtful whether the benefits gained are not more than offset by the trouble and expense involved.

There is still much to be learned about the technique of applying scientific ideas in industry. The major problems are more often psychological than technical, and the ability to tackle them depends more on the personality of the individuals concerned than on their academic achievements. Wherever possible, those likely to use the results should be in touch with the research work as it proceeds, starting sometimes to apply to new ideas before any report is issued.

It is frequently found that the economics of a procedure suggested by research can only be assessed on the plant itself. This means that large-scale trials must be organized and data collected which will enable costing to be done. Where the industry is of a type that owes its origin to scientific research, like chemicals or electronics, such trials present few psychological difficulties.

In the older industries the position is very different, there being a conscious or unconscious struggle between the craft of the 'witch-doctors' and the new ideas of the 'backroom boys'. Between these extremes lies a wide field for diplomacy, the need of the

scientific worker for more precise information on plant performance being balanced against the extra worries which such trials place on works staff

Sometimes the application of a new idea or device is delayed because of a natural desire on the part of production executives to see whether it operates successfully elsewhere before committing themselves to major expenditure. In such cases, trials on small units can often speed application to larger units. A good example of this was the application of a metallic recuperator to reheating furnaces. A new design, developed abroad, was felt to be promising, but lack of previous experience caused hesitancy in applying it on new soaking pit furnaces. The construction and exhaustive testing of a small recuperator attached to a works' furnace gave results which were sufficiently promising to lead to large-scale applications both in the United Steel Companies and in other industries.

OBITUARIES

Miss M. S. Johnston

Miss Mary Sophia Johnston, second daughter of the Rev. W. A. Johnston, rector of Acrise, Kent, was born at Folkestone on October 29, 1875, but spent the greater part of her life first at Wimbledon and then at Kew, Surrey. She became keenly interested in geology as a girl and very soon established her position among the amateurs in days when women geologists were few. Her interests lay mostly in stratigraphical and physical geology, and it was on an aspect of these that she wrote her best-known paper (with the late Miss M. C. Crosfield) on "The Ballstone and Associated Beds in the Wenlock Limestone of Shropshire".

Until age somewhat curbed her strenuous activities, Miss Johnston was a constant and energetic participant in the field meetings of the Geologists' Association (which she joined in 1898), while she had field experience of foreign geology at several meetings of the International Geological Congress, at the Toronto meeting of the British Association, and by travel in Egypt. On all these occasions she collected assiduously. Thus she built up a remarkable collection, which was always at the use of students and which she presented ultimately to the nation and to various universities. She wrote on some of her observations abroad, and also lectured extensively about them.

Miss Johnston had a life-long interest in archæology and heraldry, and compiled historical pamphlets on Richmond (Surrey) and Kew.

She was proud of being one of the first, small group of distinguished women elected as Fellows of the Geological Society of London in 1919. She served as an officer of the Geologists' Association for twenty-one years (and was made an honorary member in 1939), on the Council of the Palæontographical Society, and as treasurer of the South-Eastern Union of Scientific Societies. She was a fearless but very fair critic on committees, where she displayed a fine sense of financial rectitude.

Her scientific friends knew Miss Johnston as an ever-helpful and charming personality. It was left to those more intimate with her to know of her generosity to Kew churches and of her valuable work for youth. No account of her would be complete without reference to the active benefactor she was to one of the Richmond boys' schools and to various tradesmen's rowing organizations. She was also an officer of several of the latter and guided them wisely for many years (in one case she was honorary treasurer for more than twenty-seven years until her death).

Miss Johnston maintained her activities and interests to the last, and her death, after a short illness, on January 23 was a shock to her many friends.

H. Dighton Thomas

Mr. Eric Parker

From his schooldays at Eton until his death on February 13, Eric Parker was able to enjoy his love of the countryside. When he could no longer get about on foot, he drove himself around his beautiful garden at Feathercombe, near Godalming, in his electrically propelled chair. His last book, "Surrey Gardens", was published a year ago, and to gather material for it he visited eighty-four gardens.

Though he wrote so much on shooting and fishing, the pleasure he got from sport took second place to his interests as a naturalist. His eye was attracted by the detail of all around him: the water rat biting off the head of a lily; martins flying south as high as he had ever seen them, on a warm westerly wind in October; the change in the song of a bird; the wild-flowers of the hedgerow.

Before he joined the staff of *The Field* in 1910 to take over the shooting from James Harting, he was writing prolifically, at one time for *The Field*, *The Spectator*, *The County Gentleman*, *The Gamekeeper*, which he edited, and *The Cornhill Magazine*. At the time when he was editor of *The County Gentleman*, he formed a great friendship with Anthony Collett, for whom he did the illustrations to "British Inland Birds".

Parker never accepted any statement lightly, and this led him to analyse the observations of the early writers on natural history and to compare them with those of recent naturalists and his own. He experimented with a bow and arrow to reproduce the drumming of the tail feathers of a snipe. He held the belief that the drumming of woodpeckers is vocal, and in his "World of Birds" he gives accounts of trials he made to prove it and presents the case for and against his own conviction. He neither feared controversy nor failed to attack practices he condemned, as in his "Ethics of Egg Collecting". He hated any form of cruelty. He was opposed to tail docking of horses and dogs, and it was mainly due to his attack on the caged-bird sellers of Club Row that the traffic in wild birds was stopped. But he had no room for false sentimentality, and in 1931, after he had become editor of *The Field*, he organized a committee to consider measures to be taken against the spread of the grey squirrel.

To the Lonsdale Library, which he edited, Parker contributed much, including the volume on "Game Birds, Beasts and Fishes". The many books he wrote at his table before the window through which birds flew in to the food tray were in the purest and simplest English. Anyone reading the 'week-end' books alone could add much to his general knowledge.

On the day of Eric Parker's funeral an incident occurred which it would have given him pleasure to watch. Two of his grandsons saw a field mouse by the roadside which the youngest one gently handled and released.

R. N. Rose

NEWS and VIEWS

The European Organization for Nuclear Research : Director-General

Prof. F. Bloch is resigning from his appointment as director-general of the European Organization for Nuclear Research as from August 31, and will be succeeded by Prof. C. J. Bakker, professor of physics in the University of Amsterdam. Prof. Bakker was born in 1904 and studied physics under Zeeman in Amsterdam. In 1931 he took his doctorate (cum laude) for research on the Zeeman effect in the spectra of the noble gases. After this he spent a year in London at the Imperial College of Science and Technology, continuing his work in the field of spectroscopy. In the following year he became a member of the scientific staff of Philips of Eindhoven, where he did research on certain physical problems in relation to radio. However, his interests turned to nuclear physics, and during the War, in collaboration with Prof. Heyn, he started designing a cyclotron for Philips. In 1946 he succeeded Gorter as professor of physics and director of the Zeeman Laboratory of the University of Amsterdam. He also became director of the Institute of Nuclear Physics, the focal point of Dutch nuclear research.

Progress Medal of the Royal Photographic Society : Dr. Julian H. Webb

Dr. Julian H. Webb, of the Research Laboratories, Eastman Kodak Company, Rochester, N.Y., has been awarded the Silver Progress Medal for 1954 of the Royal Photographic Society for an outstandingly important series of studies of the photographic process extending over many years. By a combination of theoretical argument and experiment, he has established some of the fundamental facts which must be accounted for by any theory of formation of the latent image, and followed this by important contributions to the main body of the theory of sensitivity which is accepted to-day, including one of the first discussions on modern lines using the wave-mechanical theory of crystals. He has also made investigations of great value into the connexions between the sensitivity properties of single grains and the *H*. and *D*. curve of photographic materials.

Felice Fontana (1720–1805)

Felice Fontana, who died at Florence one hundred and fifty years ago on March 9, 1805, was a versatile scientist who made many original contributions to anatomy, histology, botany and toxicology. He was born on April 15, 1720, at Pomarole, near Rovereto, in the Austrian Tyrol, and studied at Verona, Padua and Bologna. While he was professor of philosophy in the University of Pisa, he made a favourable impression on the Grand Duke of Tuscany, later Holy Roman Emperor Leopold II, who offered him the directorship of the Natural History Museum at Florence. This Museum housed the finest anatomical collection known at that time, including the world-famous coloured wax preparations modelled after Mascagni's dissections. Fontana's observant and creative mind expressed itself in many scientific pursuits. As a botanist he made a careful study of the rust of grain and of spurious ergot. As an ophthalmologist he described what is to-day universally known as Fontana's canal or space. As a histologist he was one of the first to recognize the cell nucleus, the tubules of the kidney, and the nerve sheaths. As a toxicologist he investigated the actions of opium, of prussic acid and of snake poisons. His book, "Ricerche fisiche sopra il veleno della vipera" (1767), is a landmark in the study of serpent venoms. As a chemist, he found that carbon absorbs gases (this was afterwards confirmed by Priestley), and as a clinician he invented an apparatus for administering oxygen in phthisis. Fontana died at the advanced age of eighty-five and was buried in Santa Croce, Florence's Pantheon.

'Heavy Water' Project in New Zealand

A company known as Geothermal Development, Ltd., in which the New Zealand Government and the United Kingdom Atomic Energy Authority are the sole shareholders, has now been incorporated. This is a joint enterprise to undertake the construction of a factory and the subsequent production of heavy water and electric power from geothermal steam in the Wairakei district of North Island, New Zealand. The project has been under prolonged study by scientists and engineers in New Zealand and in the Atomic Energy Research Establishment at Harwell, in collaboration with Messrs. Merz and McLellan (consultants to the New Zealand Government on electric power) and Head Wrightson Processes, Ltd. (consultants to the Atomic Energy Research Establishment on heavy water), and last year a British mission including a number of scientists from Harwell went to New Zealand to discuss details. Geothermal Development, Ltd., is to have a nominal and paid-up capital of £30,000, one-third of which is to be provided by the Atomic Energy Authority and the rest by the New Zealand Government. The remainder of the capital requirements of the Company will be provided by loans ; those for the heavy-water plant (estimated at £2,000,000) are to come from the Authority and those for the electric power equipment (estimated at £4,000,000) from the New Zealand Government. The board of directors comprises three representatives of the New Zealand Government and two from the United Kingdom Atomic Energy Authority, and Dr. E. Marsden, a former head of the New Zealand Department of Scientific and Industrial Research, will be associated with the Board. It is envisaged that production of heavy water will begin late in 1957 and of electric power a few months later. Initial plant will produce electric power at a rate of about 40,000 kW., and a useful tonnage of heavy water for nuclear power reactors. The Authority undertakes to purchase from the company the whole of the output of heavy water, and the New Zealand State Hydro-Electric Department the whole of net electric power available. Boring and development work at Wairakei have already begun.

Observations on the Palolo Worm of the Pacific

The palolo worm of Polynesia and Melanesia has always been of intriguing interest to naturalists because of its so-called 'lunar periodicity', which is due to a rhythmic productivity of such consistency that spawning occurs each year in the month of November, always on a day or so following the full moon. Mr. C. Sorenson has observed the phenomena many times at Tokau Reef, Ovalau Island, Fiji. He describes in the *Australian Museum Magazine* (11, No. 6 ; June 1954) the brown-coloured scum suggesting an exudation from the hidden worms in the coral rock which appears in patches three to four days before the actual spawning. When this washes ashore and concentrates along the water line, it emits

a sickly decaying odour, which can be detected a hundred or more yards away. While the scum is present, the native population avoids eating red-coloured reef fish and trevally, as well as certain surface fish, including the local barracuda. Often before the main spawning there is a minor event, when broken lengths of the hind parts become swollen with the reproductive elements and break off from the main body of the worms. At Ovalau Island there are regularly two risings of the worms each year, and at the second, or major, one the shallows over the reef contain masses of worms two to three feet deep in dense patches which are acres in extent. The phenomenon occurs between 3 and 4 a.m., when the massed worm-lengths rise out of the coral rock in thick rope-like columns; at this stage individuals may be up to two feet long, but soon after reaching the surface they break up into shorter lengths, and final complete disintegration, death and putrefaction follow soon after the coming of daylight and the rising of the sun. The local inhabitants await the event with great eagerness and collect the worms literally in tons with every kind of utensil that is suitable. The catch is considered a great delicacy and is usually boiled, though some is eaten raw. While it is usual for only two risings of palolo worms to occur at the end of each year, as is the case for the Tokau Reef area at Ovalau Island, there appear to be rare departures from this rhythm. One such is reported by Mr. Sorenson for Wakaya Island, about ten miles away from Ovalau Island, where four risings occurred in quick succession in 1953 and 1954, the last occurring in January after the third quarter of the moon.

Forests and Climates in New Zealand

As a result of an extensive survey of the forests and climates in the South Island of New Zealand by J. T. Holloway (*Trans. Roy. Soc. New Zealand*, **82**, 2, 329–410; 1954), some interesting and important conclusions have been reached. An analysis of the indigenous forests has revealed many striking peculiarities of forest species and forest type distribution and behaviour in the Western Southland. These peculiarities are shown to be explicable in terms of a hypothesis which states, briefly, that the forests as a whole are in an unstable condition consequent on comparatively recent changes in regional climates; and that, as a result, an active redistribution of species is in progress with the resultant development of a wide range of new, though unstable, forest types. This hypothesis appears to have a general application in the South Island. It is shown that the phenomena discussed in this contribution are by no means peculiar to New Zealand forests, but that valid reasons can be advanced for the prominence of certain features in New Zealand forests in comparison with those of other countries. The report is illustrated by some good aerial photographs.

Further Education

THE role of a regional council for further education in the British system of education is explained in the introduction to the seventh annual report of the Southern Regional Council for Further Education (pp. 30; Reading, October 1954). Apart from the necessary background work to provide information, the Council serves as a forum for deliberation and agreement by representatives of constituent authorities, universities, technical colleges, government departments, representatives from industry and other interested persons. The Council advises constituent education authorities. It secures general advice from among its own members, and special advice from the Academic Board and Advisory Committees. Among various items referred to in the report is a paper on full-time release for the technical training of operatives in the heating and ventilating trade, and the continuation of teacher-training courses for part-time and full-time teachers at technical institutions.

"A New Development in Aids for Sub-normal Vision"

REFERRING to the communication under this title by J. Lederer in *Nature* of November 20, 1954, p. 977, A. G. Bennett, 25 Brook Avenue, Wembley, Middlesex, has pointed out that there are two errors in the algebraic calculations. H. H. Emsley, 36 Meadow Way, Letchworth, has suggested that Mr. Lederer's third-order or Seidel equations are not sufficiently accurate, and that relaxation of accommodation and the assumption of the rotating eye are not justified. Mr. Lederer agrees that there were two algebraic errors in his calculations; revised equations and a new graph show, he claims, that there is no important change in the significant region. As regards the use of third-order equations, Mr. Lederer states that their accuracy is sufficient, as evidenced by the field properties of lenses made according to them. He adds that clinical study and experience of more than seven hundred cases of sub-normal vision have convinced him that there is no significant accommodative activity in the great majority of such patients, and that they engage in eye movements as well as head movements and movement of the printed matter. Many have obtained much better results with such single-lens microscopic lenses giving a large, well-corrected field of view than with compound magnifiers of equal or even higher magnification with a small corrected field.

Nairobi Scientific and Philosophical Society: Officers for 1955

THE eighth annual general meeting of the Nairobi Scientific and Philosophical Society was held in the Town Hall, Nairobi, on January 28, 1955, at which the following officers were elected for the forthcoming year: *President*, Mr. D. A. Davies; *Vice-Presidents*, Dr. H. C. Pereira, Mr. H. W. Gill and Dr. H. H. Storey; *Joint Honorary Secretaries*, Mr. J. P. Henderson and Mr. J. Glover (P.O. Box 931, Nairobi); *Honorary Treasurer*, Mr. R. W. Walmsley; *Honorary Librarian*, Dr. D. W. Duthie; *Committee Members*, Mr. R. W. Rayner, Mr. H. B. Stent, Mr. C. J. Martin, Mr. H. E. Watson and Dr. C. C. Webster.

Conference on Cloud-Chamber Techniques

A CONFERENCE on "Recent Developments in Cloud-Chamber and Associated Techniques" will be held in the Department of Physics, University College, London, during March 24–26. There will be sessions devoted to the diffusion cloud chamber, the multi-plate cloud chamber, the high-pressure cloud chamber, the bubble chamber, the interpretation of cloud chamber photographs, counter control systems for cloud chambers, and to overcompression and fast recompression techniques. The conference will be held under the joint auspices of the Physical Society and University College, London, and members of the Physical Society are invited to attend. Further

information can be obtained from the Secretary, Department of Physics, University College, Gower Street, London, W.C.1.

Society for General Microbiology: Annual Meeting

The twentieth general meeting of the Society will be held in the Royal Institution, Albemarle Street, London, W.1, during April 18–20. The sessions on April 18 will be occupied by the presentation of original papers, and in the evening the second Marjory Stephenson Memorial Lecture will be given by Prof. C. B. Van Niel, of the Hopkins Marine Biological Station, Pacific Grove, California, on "Natural Selection in the Microbial World". On April 19 and 20 there will be a symposium on "Mechanisms of Microbial Pathogenicity". The principal contributions have been collected and will be published as a book which will be made available before the meeting (members of the Society, 15*s*.; others, 25*s*.). At the meeting the published papers will be taken as read and the two days devoted mainly to discussions following short summaries or commentaries on the published material by the authors concerned. Applications for the book must reach the General Office of the Society, c/o Institute of Biology, Tavistock House, Tavistock Square South, London, W.C.1, by March 15.

University of Sheffield

The Department of Fuel Technology of the University of Sheffield, which has been traditionally connected with the properties and combustion of coal and coke, has for some time extended the training of its undergraduates to equip them for careers in chemical engineering as well as fuel. It has become increasingly difficult to separate fuel technology from chemical engineering, and there is a very great demand from all types of industry for chemical engineers. In recognition of this trend, the Department has changed its name to the Department of Fuel Technology and Chemical Engineering and will train students for careers in the fuel-supplying and fuel-using industries, such as the steel industry, plant designing, and oil–chemical and coal–chemical, heavy and light chemical industries.

The following appointments have been made in the University: Mr. R. W. Douglas, at present a member of the Research Laboratories of the General Electric Co., Ltd., to the chair of glass technology in succession to Prof. H. Moore, who is retiring; Dr. G. K. T. Conn, senior lecturer, to be reader in physics; Dr. Gilbert Forbes, senior lecturer, to be reader in forensic medicine; D. Hardwick, to the C. H. Desch research fellowship in metallurgy; and Dr. N. M. Waldron, to the research fellowship in chemistry offered by the Birmingham Chemical Co., Ltd.

Announcements

Her Majesty Queen Elizabeth the Queen Mother has been elected Chancellor of the University of London in succession to the Right Hon. the Earl of Athlone.

The Physical Society has made the following awards for 1955: *Charles Chree Medal and Prize*, Dr. D. F. Martyn, chief scientific officer of the Radio Research Board, Commonwealth Scientific and Industrial Research Organization, Australia; *Duddell Medal*, Dr. R. Kompfner, of the Bell Telephone Laboratories, Inc.; *Charles Vernon Boys Prize*, Dr. J. W. Mitchell, reader in experimental physics in the University of Bristol.

Dr. J. H. Watson has been appointed chemist and assayer of the Royal Mint in succession to Mr. W. A. C. Newman, who has retired.

Dr. Rhodes W. Fairbridge, lecturer in geology in the University of Western Australia, has been appointed professor of geology in Columbia University, in succession to Prof. A. K. Lobeck, who has retired.

Three Ramsay Memorial Fellowships, normally tenable for two years and worth £450 a year plus a grant for expenses of research not exceeding £100 a year, are being offered for chemical research. One of the Fellowships will be limited to candidates educated in Glasgow. Further information can be obtained from the Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College, Gower Street, London, W.C.1, to whom application forms must be sent not later than April 21.

Two scholarships, tenable at research institutions in France during the academic year 1955–56, are being offered to British workers in medical science, excluding clinical medicine, by the Medical Research Council on behalf of the Centre National de la Recherche Scientifique. They are intended for young British graduates in medicine or science who have already had some experience in a branch of medical science, and are worth 50,000–70,000 francs a month, with a supplementary allowance, payable in sterling, for married men. A working knowledge of French is essential. Application forms, to be returned by March 31, and further details can be obtained from the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1.

The Royal Dutch-Shell Group of Oil Companies is offering two research studentships in geophysics, of value £450 a year (£500 for married men) and tenable for two to three years at the University of Cambridge, which are open to men of any nationality less than twenty-seven years of age on October 1. Further information can be obtained from Mr. B. C. Browne, Department of Geodesy and Geophysics, Downing Place, Cambridge, to whom application forms must be sent not later than June 1.

A Symposium on Intermetallic Semi-conductors will be held at the Services Electronics Research Laboratory, Baldock, Herts, during April 26–27. Further information can be obtained from I. M. Ross at the Laboratory.

The seventh of the international symposia on crop protection that are held in Ghent each year will take place on April 26, and will coincide with the quinquennial Floralias of Ghent. Those wishing to read a paper must submit it before March 10. Further information can be obtained from the president of the organizing committee, Prof. J. van den Brande, State Agricultural College, Coupure Links 233, Ghent.

The sixth Students Biological Conference will be held in the Biology Departments of the University of Birmingham during March 27–April 1. Undergraduate and postgraduate students are invited to read papers (not necessarily the outcome of original research work) and reviews; to exhibit collections; and to present demonstrations of field and laboratory work and techniques, etc. The programme will include a conversazione and visits to places of biological and general interest. Further information can be obtained from the Conference Secretary, Botany Department, University, Birmingham 15.

CO-OPERATION IN ENGINEERING RESEARCH BETWEEN EDUCATIONAL INSTITUTIONS AND INDUSTRY

A GROUP of three papers on co-operation in engineering research between educational institutions and industry was presented for discussion at a meeting of the Education Group of the Institution of Mechanical Engineers on January 28. The first paper of the group was by Prof. E. Giffen, of Queen Mary College, London, comparing the magnitude of the co-operation in engineering research in Britain and in the United States. Estimates of the amounts of money contributed by government departments and by industry to support research in engineering departments of universities and colleges (either in general or on specific projects) showed that the expenditure in the United States is more than a hundred times the figure for Britain. Taking the facilities available for research in terms of staff and laboratory accommodation as proportional to the numbers of full-time students, it appears that, if British educational institutions were used to the same extent as those of the United States for co-operation in research with industry (including government departments), our expenditure on this work would be increased more than ten-fold.

Prof. Giffen mentioned some of the reasons for this disparity in the amount of co-operation in the two countries and suggested that the real difficulties lie in ignorance, both in industry and in the universities, of the other side's point of view, and that many of these difficulties could be cleared away by full and frank discussion by those concerned. He went on to consider the desirable upper limit to co-operation in research, taking as criterion the benefit to the teaching work of a university department; the limit is reached when the staff are doing as much research as is consistent with their continuing to take an active and effective part in teaching. Although there is evidence that the amount of co-operation in some universities in the United States has passed this limit, we in Britain have a very long way to go before we need have any fear of that.

The second paper in the group, by Mr. V. C. Davies, was concerned mainly with engineering research in technical colleges in co-operation with industry. He stressed the opportunities for part-time research students to investigate problems encountered in the course of their work in industry. The time that can be devoted to the work is often much greater than that spent in the college, and the rate of progress can be surprisingly fast. Mr. Davies is of the opinion that special staff are necessary to supervise research, perhaps on a part-time basis, and special care is needed in selecting suitable subjects for research from those suggested by students from industry. Many of these suggestions are concerned with development of a particular machine or component; while some are better left to industry, others can be investigated jointly, the firm providing its own staff for parts of the work and the college undertaking the more fundamental aspects.

Mr. Davies pointed out the opportunities for more sponsored research, and its benefits to both colleges and industry. The question of publication of results need not cause any difficulty. The main reason why more systematic research is not conducted by the teachers in technical colleges is their heavy load of teaching. Until recently, all such teachers were, and many are still, required to spend about twenty hours each week with students; this, with the additional time taken in the preparation of lectures and the reading of students' work, left little time for research by the conscientious teacher. Recent changes have enabled some of the larger technical colleges to reduce the amount of teaching required of the staff, and this should make a marked improvement in the opportunities for research.

The third paper, by Mr. J. H. R. Nixon, was written from the point of view of the small and medium-size organizations engaged in the manufacture of engineering equipment. The need for more research and development is becoming more widely recognized, and with it the desire for more co-operation with educational institutions. Sponsored or contract research is a suitable method for dealing with well-defined projects, with short-term or medium-term objectives, and where specific information is required which is beyond the company's resources. In many cases it is found that the investigation of such special problems requires parallel research on fundamental lines, leading to results of general interest and with wide applications.

Mr. Nixon's experience has shown that the greatest benefit is derived if a member of the firm's staff participates in the work as it proceeds. The man might be seconded to work full-time in the university; apart from the results of the particular investigation, the experience is valuable and enhances his worth on his return to his firm. But part-time participation can also be very successful, because then the man can apply the results of his research to improvements in design or production as the research proceeds. No better integration of research and development can be obtained than by organizing them to go on side by side, either by a team of workers or by a single man, depending on the nature of the project. In Mr. Nixon's opinion, firms are not sufficiently informed about the specialized facilities available to assist them with research and advice. Closer contact is desirable between industrial designers and development engineers and the staffs of universities and technical colleges. One way of achieving this is through the use of professors as consultants on plans for research and development—a method much more extensively practised in the United States than in Britain.

Dr. D. Clayton, who opened the discussion, emphasized the need for care in choosing suitable research problems as a basis for co-operation, and indeed in choosing all subjects for research students, to avoid wastage of man-power. Those concerned with new problems in industry should separate them into different categories according to the extent to which they involve fundamental work or practical techniques and then decide which could be investigated inside the organization; the others, mainly those involving fundamental studies, should be handed over to suitable university departments, establishments of the Department of Scientific and Industrial Research or industrial research associations.

Other speakers gave examples of the way in which co-operation in research has increased in recent years

and of the benefits both to industry and to the university staff. Special mention was made of the close contact between the Ministry of Supply and university departments of aeronautical engineering and also of the Ministry's scheme for employing university teachers as vacation consultants. Suggestions were made for better methods of communicating information about the results of research, and about research in progress. Higher-degree theses are quite unsuitable for general publication, and the results should be re-written at different levels to suit the different kinds of readers to whom the results would be useful. It was suggested that abstracts of all higher-degree theses should be deposited with a central organization, such as the Department of Scientific and Industrial Research, which would bring the work to the notice of interested people.

Postgraduate courses for men in industry provide an effective research contact between industry and universities. The courses might be of long or short duration, but should include some experience in the investigation of problems relevant to the industry. On the other hand, it was pointed out that many of the students attending such courses, and indeed a large proportion of the students engaged on research for higher degrees, come from overseas countries, with the financial support of their governments, and will bring no direct benefit to industry in Britain. If industry were really convinced of the benefits of research and postgraduate courses as a training for its young engineers, it should send more of them back to the universities, either full-time or part-time; this in itself would be a valuable method of maintaining closer contact and promoting co-operation between industry and educational institutions.

AIRFLOW OVER MOUNTAINS

A DISCUSSION meeting was held on the subject of the "Airflow over Mountains" in the rooms of the Royal Meteorological Society on January 19. The subject poses an interesting problem in hydrodynamics, and also has implications of considerable importance to aviation; accordingly, many visitors having an interest in the aviation aspects attended. The discussion was opened by Mr. G. A. Corby, of the Meteorological Office, who gave a summary of the state of knowledge of the subject.

Stationary lenticular clouds can often be seen both over and to the lee of hills and mountains, strongly suggesting that systems of waves can be initiated in an airstream by topography. Cirrus clouds at 20,000 ft. or more, too, are believed to be due sometimes to the topography below; while over the Norwegian mountains so-called 'mother of pearl' clouds can be seen on rare occasions at some 70,000–80,000 ft. Clearly, the influence of mountains on the airflow above can be much more than an intensification of turbulence. Glider pilots have contributed much useful observational evidence of these special airflow effects, and their experience leads to a certain conception of what an atmospheric lee wave system is like. By exploiting the up currents in such waves, gliders have exceeded 15,000 ft. over hills of moderate size in Britain, while they have penetrated well into the stratosphere in the powerful wave systems of the Sierra Nevada in California. Powered aircraft also are affected by these vertical currents, which occasionally may be sufficiently intense to constitute a hazard. Aircraft flying over or near mountains sometimes pass through alternate regions of lift and sink; these regions may not be accompanied by any significant turbulence and, indeed, remarkable smoothness is sometimes reported. Vertical currents of a few hundred feet per minute are, apparently, quite common, while on extreme occasions smooth vertical currents exceeding 2,000 ft./min. have been encountered by aircraft in Europe.

The hydrodynamical problem of the laminar, frictionless and isentropic flow over an idealized two-dimensional ridge has been studied by several workers, using perturbation theory. Prof. P. Queney confined himself to a uniform airstream, that is, one in which the static stability and wind in the undisturbed stream were constant, and found that the nature of the flow depended very much on the scale of the problem. For a very small hill, neither stability nor geostrophic forces were relevant, and his solution gave a single smooth disturbance over the hill. For a hill of a few kilometres in width, the stability became important, and a more complicated disturbance affected the flow above the hill throughout the depth of the airstream. For a large mountain ridge of about 10 km. in width, his solutions predicted a lee wave system. On examination, this wave system proves to be mainly a horizontal oscillation about the geostrophic wind, having a long wave-length of some hundreds of kilometres. Although such waves probably occur in the atmosphere, they cannot be responsible for the vertical currents which embarrass aircraft and are exploited by gliders.

In Dr. R. S. Scorer's theoretical work, provision was made for variations of static stability and wind in the vertical. A certain function of the wind and stability proved to be a parameter of fundamental importance in the problem, and Scorer has shown that for realistic lee waves to be possible in an airstream, a decrease in this parameter with height is necessary. The condition can be fulfilled in practice by the presence of a layer of marked stability (or an inversion) at middle levels, with less stable air above, or by a substantial increase in wind with height, or by some combination of these two effects. Perturbation theory calculations for the flow of such an airstream over a mountain predict a system of lee waves which accords well with observational data. The waves have a wave-length of a few kilometres, and after attaining a maximum amplitude at some level, they die away at greater heights, sometimes slowly, sometimes quickly. An example of the theoretical streamlines calculated for a particular case is given in Fig. 1; the relevant temperature and wind profiles are indicated at the left of the diagram. Examination of the characteristics of the airstreams in which mountain waves have been encountered by aircraft shows that the conditions are consistent with those deduced theoretically by Scorer. The theory could be exploited qualitatively for the preparation of advice to aviation interests; but it would be difficult to apply the theory with any precision because of the complications of the atmosphere and of mountainous terrain in general.

Dr. J. Förchtgott, an expert Czech mountain glider pilot, has carried out a series of field investigations over several mountain ridges of Central Europe, using teams of gliders, light aircraft and special ground observations. He found that no organized pattern of airflow could be discerned unless the airstream had stable or neutral stability, and the wind direction was fairly constant with height and

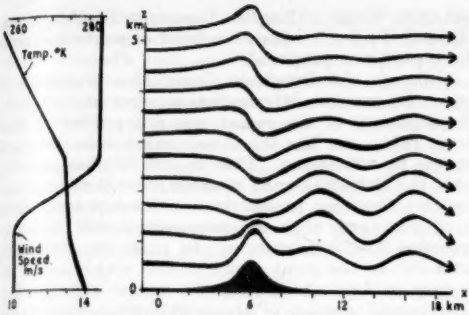

Fig. 1. Theoretical stream-lines for the flow over a mountain ridge under conditions favourable for lee waves

roughly perpendicular to the mountain ridge. Subject to these conditions, the type of flow depended on the wind. For moderate winds, a large semi-permanent standing eddy was often observed in the lee, with reversed flow up the lee slope. With stronger winds increasing with height, a lee wave system developed, often with lenticular (wave) clouds aloft and rotating clouds in the wave crests at heights comparable with that of the mountain top. With very strong winds extending through a restricted vertical depth, that is, when, above the friction layer, there was reversed wind shear in the vertical, Förchtgott found that heavy turbulence occurred, due, he believed, to the formation of a system of vortices rotating in opposite directions and having features similar to the Kármán vortex street of hydrodynamics. He named the latter flow type 'rotor streaming'. Theory can as yet make no predictions as to the nature of such non-laminar flow patterns.

Mr. A. Yates described more recent work by Dr. Förchtgott in which he has elaborated his diagnosis of the flow types. From observations of lenticular clouds he has concluded that mountain waves sometimes move slowly downstream, to be followed sometimes by apparent rapid movements upstream. During the course of the meeting it was suggested that complicated interference must occur between the wave trains from separate orographic features, and this, coupled with random or systematic changes in the airstream characteristics, might well account for apparently erratic changes in the wave-length and amplitude of atmospheric wave systems.

Mr. C. E. Wallington gave an account of a calculation of the flow over a section of the Derbyshire countryside on an occasion when a marked wave system was encountered during a glider flight. A close approximation to the topography was achieved using five Fourier integrals, and the profiles of static stability and wind were obtained from meteorological upper air data. Synthesis of the five flow patterns obtained by perturbation theory gave the theoretical flow over the actual topography. A useful measure of agreement between the observed and calculated flows was demonstrated.

Prof. G. Manley described some observations of the striking wave phenomena which sometimes occur with strong easterly winds over the Crossfell escarpment in Cumberland. The question of separation of the flow and the formation of eddies was discussed by Dr. R. S. Scorer, who demonstrated the part played by viscosity in encouraging eddy formation. Katabatic winds and such effects would discourage eddies; but on the whole it appeared that the shape and steepness of the lee slope were the most important factors in determining separation. Such effects near the surface could have a profound effect on the flow at much greater heights, because the effective shape of a hill becomes completely changed by the presence of a lee eddy.

Research into the possibility of exploiting wind-power for the generation of electricity has stimulated the collection of wind data from hill tops in Britain. Mr. H. H. Rosenbrock reported that an increase of up to 40 or 50 per cent in wind speed is to be expected over hill crests, and as the power available from wind varies as the cube of the speed, the increase is important. In the case of a long ridge, the increase in speed arises from the compression of the stream-lines over the crest; but a similar increase is also attained over an isolated hill because much of the flow at low levels passes around the hill, and accordingly the crest-level flow is derived from a higher level.

Mr. K. W. V. Townsend discussed the distribution of tree damage from gales in hilly country. Although this is complicated because of the variation of tree growth with altitude and soil properties, nevertheless the distribution was clearly dominated by the local distortion and intensification of the wind-flow by the terrain.

The closely related subject of orographic rainfall was discussed by Mr. J. S. Sawyer, who pointed out that rainfall totals over 12 or 24 hr. were on much too coarse a time-scale to reveal the effects on rainfall of complicated and changing atmospheric waves. However, it was clear that the increase in rainfall over hilly terrain was often significant to the lee as well as over the crests and windward slopes. He had noted also that the increase was commonly much more marked to the south of depression tracks than to the north; an explanation could be that the wind structure to the south (normally an increase with height) would be more favourable for orographic disturbances to the airstream than to the north (where there would normally be reverse wind shear).

Mr. H. S. Turner put forward the suggestion that there might be an association on some occasions between high-altitude clear air turbulence, sometimes encountered by high-flying aircraft, and topography. The idea is gaining favour, and Dr. Scorer has pointed out that mountain waves could provide the mechanism for the generation and maintenance of the large shears of wind which appears to be necessary for such turbulence.

Some pilots of British European Airways described their experiences in flying through mountain waves and turbulence, and Mr. R. K. Pilsbury, of the meteorological office, Northolt Airport, gave brief details of an analysis of such aircraft observations.

G. A. Corby

THE BRITISH COUNCIL

ANNUAL REPORT

APART from the chapter dealing with the welfare of overseas students, the portions in the report on the work of the British Council for the year ended March 31, 1954*, of most direct interest to the scientist are those discussing university interchange and the written and recorded word.

* Report on the work of the British Council for the year ending 31st March 1954. Pp. v+105. (London: British Council, 1954.) 2s. 6d.

The value of the work of the Council on university interchange was acknowledged at the Seventh Congress of the Universities of the Commonwealth in July 1953, and for the development of such services the Council depends largely on the co-operation of the universities and on the advice of its Universities Advisory Committee. Details of the interchange service with thirteen European countries, whereby during each academic session the British universities invited fifty-four distinguished scholars to Britain and in return a similar number of invitations were extended to British university teachers for the period 1948–53, have already been given.

The Anglo-Belgian Mixed Commission has recently suggested that some of the younger university scientists who are doing original work of particular interest might profit from the opportunity of consultations overseas with research workers in their own fields of study. Such interchange visits have already been arranged between the United Kingdom and Belgium, and it is hoped to extend the scheme to younger university scientists in other countries. More than a hundred scholarships tenable in the United Kingdom are now offered annually by the British Council to students from other countries, and a like number are offered to British students for study in fifteen European countries. Among the short visits for consultation and lectures under the Commonwealth scheme for which awards were made during the year are those of Prof. P. A. Giguère, of Laval University, to the United Kingdom, of Dr. F. C. Phillips, of the University of Bristol, to Australia, and of Sir Arthur Carr-Saunders to South Africa. Thirty-six awards were made for study in the United Kingdom and twelve for study in other Commonwealth countries. Under the foreign visits scheme, 31 awards were made for short visits from twelve countries to United Kingdom universities, and 43 awards for visits to universities in ten foreign countries.

It is an essential part of the Council's work to use books and periodicals as extensively as its funds permit. Export figures of English periodicals are unknown; but the annual export trade in books exceeds £14 million and nearly half the books published in Britain go overseas. But there are important countries which can find no sterling for the purchase of British publications, and others have few or no competent booksellers; in some areas the British trade has not yet established itself. The British Council libraries may thus be the only sources from which would-be readers of English can meet their needs. The Council's work is concerned first with publicity chiefly for new British work of all kinds, including book exhibitions, the forwarding of books for review, and the issue of the *British Medical Bulletin*, *British Book News* and the *British Agricultural Bulletin*. Each issue of the first of these deals with a single aspect of medical science, the subjects covered in 1953–54 being enzyme research, viruses in medicine, reactions to injury and tuberculosis. A second department deals with the supply of printed matter to libraries, schools and other institutions, and also with requests for bibliographical information. During the year, the small increase in the grant for books had surprisingly effective results; but annual replacements of about five per cent of stocks are still below the fifteen per cent required. Thirdly, the Council's work in this field includes the production of publications such as the supplements to *British Book News* on "Writers and their Work", "English Language Teaching" and "Britain To-day", which has been discontinued since the report was prepared.

Although the Drogheda Committee presented its report on overseas information services in July 1953, the summary of the report was not published until April 1954; nor has the Government even yet made known its intentions. That report emphasized that what the British Council requires more than anything else is a five-year programme of developments, with some guarantee that the necessary funds would be provided for its execution. In particular, directing attention to the great opportunities which await the Council in Asia and Africa, the report recommended an eventual increase of about £630,000 a year in the Council's vote.

In the uncertainty as to whether the Government is prepared to accept any of the recommendations of this report, the Council has already been forced to make economies in its work in Europe; but it has been allowed to retain the proceeds and to re-invest them in work elsewhere, while some additional money has been granted to meet the Council's rising operating costs. On the question of this contraction of its work in Europe, however, the Council has some misgivings. It gives reasons for believing that in detail the Drogheda Committee over-estimated the extent of the savings to be achieved by further curtailing that work (which has already been cut by fifty per cent over the past five years). More important, it questions the attitude to Europe disclosed in the report and is doubtful whether it is wise to rely solely on casual contacts in the face of a manifest anxiety for increased British cultural activity and co-operation in Europe.

While recognizing the greatness of its opportunities and responsibilities in Europe, the Council remarks: "It would be an exaggeration but not an untruth to say that a much closer understanding of the Englishman and his ways exists at Karachi than at Lyons, partly because Englishmen are a more familiar sight in one city than in the other, and partly because an outward similarity of culture helps to mask a basic difference of mental approach". The Council believes that the Drogheda Committee has misconstrued the importance of the work in Europe, because it has failed to appreciate that the Council's work has an element of disinterestedness as well as a representative aspect. The Council exists as a body which helps to interpret overseas the permanent features of the British way of national life and to make available to the rest of the world the British contribution to knowledge, welfare or enjoyment. If, however, the Council is always to aim at producing a definable political or commercial benefit for the country, it will lose the advantage it possesses over a government information department.

It is a sound point that the British Council must sometimes do something for its clients simply because it is what the client wants, unless the idea is to grow that there is always a material motive behind its activities. The point should not be pressed too far; but it is political wisdom that an independent body should not neglect its opportunities of disinterested service. In Europe, in Africa and in Asia alike, such a policy may yield rich returns in international goodwill and understanding.

Apart from these comments, the Council welcomes the Drogheda report, while expressing the reasonable hope that the stage of repeated major investigations (of which the Drogheda inquiry was the third in seven

years) has been passed. The Drogheda report has established beyond question the national importance of the Council's work and the efficiency with which it is carried out. It has also established the importance of continuity of planning and finance, and of stable and secure conditions of service. To implement the recommendations to that end would be comparatively inexpensive and is imperative, irrespective of whether or not the Government is prepared to provide the additional resources which would enable the Council to seize the opportunities in Asia and Africa, the reality of which is amply confirmed in the present report.

Since the report was published, the Government has stated in the House of Commons that it proposes to provide an additional £100,000 in the present and next financial years for the expansion of the overseas information services. In particular, it is proposed to strengthen the information services in South-East Asia, the Middle East, Latin America and Canada; to improve the Central Office of Information Press Service and the supply of films for use overseas; to strengthen the Council offices in South-East Asia and Japan, establish new offices in Kuwait in the Persian Gulf and in British Honduras and re-open an office in Persia. Full participation by the Government in the growing cultural activities of the Brussels Treaty Organization and of the Council of Europe is also proposed.

PHYSIOLOGY OF STOMATA

THE seemingly evergreen topic of the physiology of stomata has evoked a number of further contributions by contemporary investigators. M. Shaw and G. A. Maclachlan (*Canad. J. Bot.*, **32**, 6, 784; 1954) have studied the carbon dioxide fixation in stomatal guard cells. By exposing the epidermis of species of *Tulipa*, *Hordeum*, *Tradescantia* and *Allium*, in which only the stomatal guard cells possess chlorophyll, to radioactive carbon dioxide, followed by microautoradiography, they have demonstrated the selective uptake of carbon dioxide by the guard cells in the light. A less intense uptake was observed in the dark with *Allium*, *Sedum*, *Tulipa* and *Vicia*. The rate of guard-cell synthesis, which was estimated for *Tulipa gesneriana*, appeared to be too low to account for the increase in osmotic potential caused by illumination. These investigators note that since the opening of stomata is promoted by low carbon dioxide tension, even in darkness, the removal of free carbon dioxide, or an effective lowering of its tension, by guard-cell activity, is probably more important in stomatal opening than the direct photosynthesis of osmotically active solutes in the guard cells.

In a new theory of the mechanism of stomatal movement, W. T. Williams (*J. Exp. Bot.*, **5**, 15, 343; 1954) advances the ideas that the important movement is that of closure, that this is a positive or active process, and that the carbohydrate changes so frequently reported are secondary, 'stabilizing' changes, probably not directly linked to the main process. The evidence for this conception of stomatal activity is discussed and some of its implications considered. It is accepted that stomatal movements are primarily the result of turgor changes. In expounding the theory the author directs attention to the many remarkable parallels between the movements of sensitive plants and of stomata. Reference is made to Weintraub's explanation of pulvinar movement in *Mimosa*, in which it is held that the rapid expulsion of water from the cells of the pulvinus is effected by way of contractile vacuoles, and to the movement of water in protozoa and unicellular algæ. In these micro-organisms this water movement is energy-assisted—a process which allows for the movement of water as distinct from solution, independent of osmotic gradients. To quote the author on the subject of stomata: "If dark induced loss of turgor is an energy-assisted process, how, during the ensuing hours of darkness, is it maintained? Must water be continuously pumped out to maintain the flaccid condition? It would appear so: for the theory postulates that the turgid condition is osmotically the position of rest, to which the cell must return if contractile forces are withdrawn—as occurs in light, or even, in response to an autonomic stimulus, in the unchanging darkness".

E. W. Yemm and A. J. Willis (*New Phyt.*, **53**, 3, 373; 1954) have made a study of the diurnal movements of the stomata of *Chrysanthemum maximum* by means of porometer measurements of leaf resistance and by examination of epidermal strips. The amounts of sugar and starch in the epidermis and mesophyll were estimated. A highly significant correlation was demonstrated between the starch content of the guard cells and pore-width or leaf resistance. The opening of stomata in the morning was associated with a decrease in starch and an increase of sugars in the epidermis together with a fall in the water content of the leaf. The stomata closed when the water deficit exceeded 5 per cent of the water content of the fully turgid leaf. The closure was associated with an increase of starch in the guard cells; but there was no corresponding fall in the sugars of the epidermis. The total carbohydrates of the epidermis showed a distinct diurnal fluctuation which was in some respects like that of the mesophyll. In the light of this investigation the authors suggest that the diurnal movements of these stomata under natural conditions are mainly determined by the water relations of the leaf tissues and carbohydrate changes in the guard cells.

AN EXPERIMENT ON THE INHIBITION OF THERMAL CONVECTION BY A MAGNETIC FIELD

By DR. YOSHINARI NAKAGAWA

Hydrodynamics Laboratory, Department of Meteorology, University of Chicago, Chicago

THE character of the thermal instability of a layer of incompressible liquid heated from below has been the subject of both experimental and theoretical investigation since Benárd's[1] discovery of cellular convection in those circumstances. The principal results established by these investigations are: (1) that a layer of fluid heated below first becomes unstable when the Rayleigh[2] number, $R = \frac{g\alpha\beta}{\varkappa\nu} d^4$ (where g denotes the acceleration due to gravity, d the depth of the layer, β is the adverse temperature gradient which is maintained and α, $\varkappa$ and ν are the coefficients of volume expansion, thermometric con-

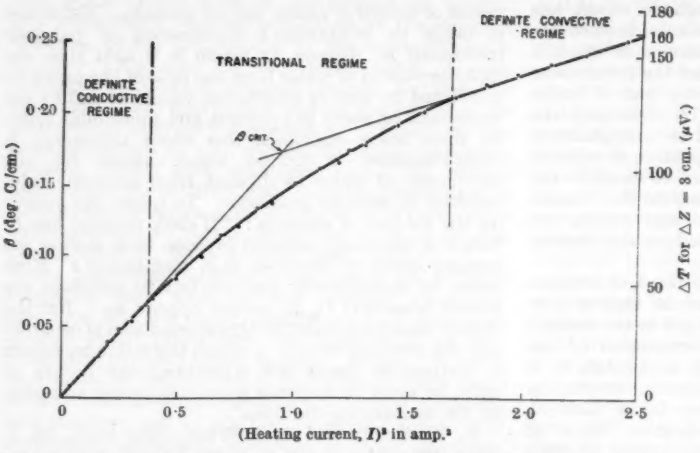

Fig. 1. Temperature gradient at various rates of heating. Experimental points are for temperature gradient measured at 1 cm. and 4 cm. levels in 5 cm. depth of mercury. Average magnetic field around central plane, 1,500 gauss.

$$R_c = \frac{\alpha\beta_{eq}}{\kappa\nu} d^4 = 3{\cdot}82 \times 10^5; \quad Q = \frac{\mu^2\sigma |H|^2}{\rho\nu} d^2 = 3{\cdot}37 \times 10^4$$

ductivity and kinematic viscosity, respectively), exceeds a certain determinate value of the order of 1,000; and (2) that the motions which ensue have a cellular pattern in agreement with Benárd's observations. The exact value of the Rayleigh number at which instability first sets in depends on boundary conditions, such as whether the plane surfaces between which the layer of fluid is confined are free or rigid (cf. Jeffreys[3] and Pellew and Southwell[4]); and the values which have been derived theoretically have been confirmed by several experimenters[5,6].

Chandrasekhar[7] has recently re-examined this problem for the case of a layer of electrically conducting liquid heated from below and when an external magnetic field is impressed on the liquid. The principal result of his study was to establish that the presence of the magnetic field delays the onset of convection; and that the critical Rayleigh number at which instability sets in depends on the strength of the magnetic field (H) and the electrical conductivity (σ) of the fluid through the non-dimensional parameter $Q = \frac{\mu^2 H^2 \sigma}{\rho\nu} d^2 \cos^2\vartheta$, where μ denotes the magnetic permeability of the liquid and ϑ the inclination of the direction of H to the vertical. In his paper, Chandrasekhar has derived the $R(Q)$-relation for different boundary conditions (for example, both bounding surfaces rigid, both bounding surfaces free and one bounding surface rigid and the other free).

The experiments to be described below were designed to investigate the critical values of the Rayleigh number predicted by Chandrasekhar for different values of Q with mercury as the electrically conducting liquid. The external magnetic field was provided by a permanent magnet used originally as the deflexion magnet for cosmic ray experiments and very kindly made available for this experiment by Prof. Marcel Schein, of the Physics Department, University of Chicago.

Mercury contained in a 'Pyrex' glass cylinder of 14·5 cm. diameter was placed at the centre between the pole surfaces, the magnet being placed so that the field was vertical. The average intensity of the magnetic field over the area of the glass cylinder at the central plane of the gap was about 1,500 gauss. Uniform heating was applied by an electrical heater with d.c. current beneath a copper plate at the bottom of the cylinder. A combination of sliding resistances was used to obtain various rates of heating, and to provide the relation between temperature gradient and the heating-rate as mentioned below.

The quantities, except β, in the Rayleigh number and Q were given constants at each determination, and the criterion was investigated by means of the experimental determination of the critical adverse temperature gradient. The adverse temperature gradient was measured directly in this experiment by means of a five-couple copper–constantan thermopile immersed at two fixed levels in the mercury. The thermal e.m.f. of the thermopile was amplified by a d.c. amplifier and recorded in an automatic recording milliammeter. A continuous record of the temperature gradient was obtained within an accuracy of 0·01 deg. C. for the total temperature difference between the two fixed levels.

The temperature gradient was plotted against the heating-rate and the critical temperature gradient was determined from the intersection of the extrapolated linear trends of the pure conductive region and the pure convective region of heat transfer[8]. Fig. 1 shows the experimental results for a 5-cm. layer of mercury. The regions of heat transfer indicated

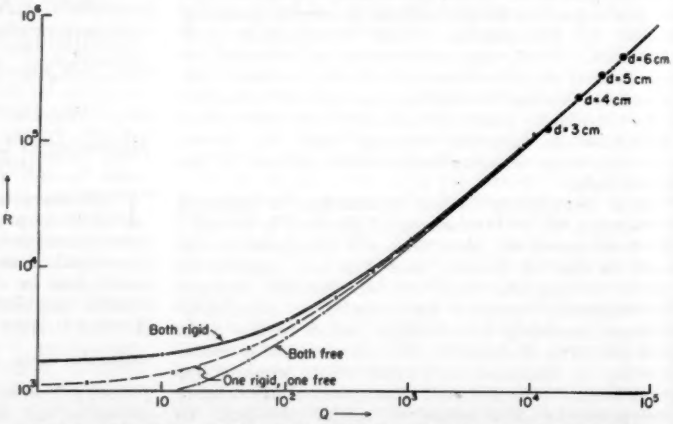

Fig. 2. Dependence of the critical Rayleigh number on Q. The curves are Chandrasekhar's theoretical curves; the experimental results are marked by circles, the depth of mercury used in each case being indicated

in the figure were determined by inspection of the time-record of the temperature gradient.

When heating is applied at the initial state of zero gradient, the adverse temperature gradient builds up gradually and follows characteristic trends in the conductive and convective regions of heat transfer respectively. In the conductive region, the temperature gradient reaches a certain limiting value and remains at that value for continuous heating. In the convective region, the temperature gradient reaches a peak value, then breaks into oscillation around a slightly lower value.

In both regions of heat transfer, empirical linear relations between the heating-rate and the temperature gradient were obtained by various experimenters[5,6,8]. Therefore, the transitional region was defined by the obvious deviation from the linear relationship, and the record of non-oscillatory breakdown.

Since the intensity of the magnetic field varied considerably within the region occupied by the container from 1,250 gauss near the outer radius of cylinder to 1,750 gauss at the top and the bottom, this transitional region most probably is due to the earlier onset of convection in weaker parts of the field.

The results of the experiment, in terms of the critical Rayleigh numbers, are shown in Table 1 for four different depths of the mercury layer, where the values of critical temperature gradient for the non-magnetic case were evaluated from the value of the critical Rayleigh number of 1,708. It may be noted that the boundary conditions that actually obtained are those for two rigid surfaces, because of the presence of a contaminant film on the top surface of the mercury.

These values of the critical Rayleigh number practically coincide with the theoretical values given by Chandrasekhar as seen in Fig. 2, where the estimated average intensity of the magnetic field of 1,500 gauss is used for Q. It is particularly striking that, in spite of the difficulties associated with the non-uniformity of the magnetic field, the theoretical slope is closely approximated by the four points in Fig. 2. Thus the experiment verifies the predicted inhibition effect on the onset of convection in an electrically conductive liquid under an external magnetic field.

Table 1

Depth (cm.)	For $\frac{Q}{H}$ = 1,500 gauss	Critical Rayleigh number obtained	Measured critical gradient temperature (deg.C./cm.)	Critical temperature gradient for non-magnetic case (deg.C./cm.)
3·0	$1{\cdot}2\times10^4$	$1{\cdot}38\times10^5$	0·478	$5{\cdot}92\times10^{-3}$
4·0	$2{\cdot}2\times10^4$	$2{\cdot}49\times10^5$	0·273	$1{\cdot}88\times10^{-3}$
5·0	$3{\cdot}4\times10^4$	$3{\cdot}82\times10^5$	0·171	$0{\cdot}768\times10^{-3}$
6·0	$4{\cdot}9\times10^4$	$5{\cdot}42\times10^5$	0·117	$0{\cdot}371\times10^{-3}$

The details of this work will be published elsewhere. The encouragement and guidance given by Prof. S. Chandrasekhar and Dr. D. Fultz are acknowledged; thanks are also due to Prof. M. Schein and Dr. C. M. York for the use of the magnet. The investigation has been made possible through support and sponsorship extended by the Geophysics Research Division, Air Force Cambridge Research Center, under a contract. [Dec. 18

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STRUCTURE OF THE ISOMERIC 2:4-DINITROPHENYLHYDRAZONES OF SOME ALPHA-KETO-ACIDS IN RELATION TO THEIR INFRA-RED SPECTRA

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AND

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THE discovery that each α-keto-acid could give two 2:4-dinitrophenylhydrazones has already been described in connexion with the separation and analysis of mixtures of pyruvic, oxalacetic and α-keto-glutaric acids on paper chromatograms[1]. The two hydrazones obtained from each α-keto-acid were provisionally regarded as stereoisomers about the —C=N— linkage, though it was not possible definitely to identify the individual isomers as *cis* or *trans*. The R_F values did not bear any simple relationship to each other, such as might have been expected by analogy with the separation of diastereoisomeric sterols on alumina[2]. In fact, they varied so widely with the α-keto-acid and the nature of the chromatographic system that the presence of steric factors other than *cis-trans* isomerism was suggested.

The present study was undertaken in order to provide confirmatory data for the structural assignment of the hydrazones as geometrical isomers and to elucidate the nature of the steric factors which affect the chromatographic properties of the isomers. For this purpose 20–30 mgm. of the isomeric hydrazones were separated on paper chromatograms, using paper which had been buffered to *p*H 8·0 (for conditions see ref. 1). The separated hydrazones were extracted with 0·2 *M* sodium bicarbonate, and under these slightly alkaline conditions were quite stable. To prepare the free hydrazones, the sodium bicarbonate extract was acidified to *p*H 2·0 with dilute sulphuric acid and extracted with chloroform containing 10 per cent ether. The chloroform extract was dried over anhydrous sodium sulphate and then

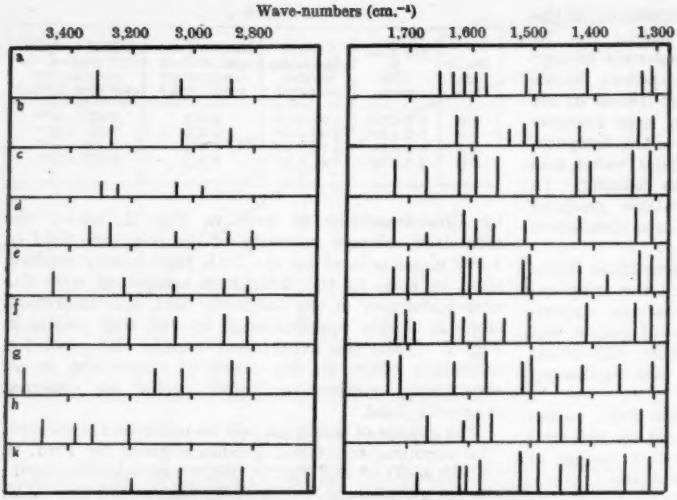


Fig. 1. Infra-red absorption spectra of:
(*a*) 2 : 4-Dinitrophenylhydrazine
(*b*) Acetaldehyde 2 : 4-dinitrophenylhydrazone
(*c*) Pyruvic acid 2 : 4-dinitrophenylhydrazone (1)
(*d*) Pyruvic acid 2 : 4-dinitrophenylhydrazone (2)
(*e*) α-Keto-glutaric acid 2 : 4-dinitrophenylhydrazone (1)
(*f*) α-Keto-glutaric acid 2 : 4-dinitrophenylhydrazone (2)
(*g*) Oxalacetic acid 2 : 4-dinitrophenylhydrazone
(*h*) Anthranilic acid
(*k*) N-2 : 4-Dinitrophenylanthranilic acid

evaporated to dryness *in vacuo*. The hydrazones were prepared as rapidly as possible, and at no time were they subjected to temperatures above 15–20°. Examination of their infra-red spectra was complete within twenty-four hours of preparation. Even so, the isomeric hydrazones of oxalacetic acid had become inter-converted sufficiently for the spectra to be indistinguishable. In the case of pyruvic acid, the change was sufficiently slow not to interfere with the interpretation of the results (equilibrium was not reached even after three to four weeks at room temperature). The hydrazones of α-keto-glutaric acid were stable.

The infra-red spectra were all obtained with the substances in the solid state and ground with a suitable quantity of liquid paraffin to form a mull. Where absorption of the paraffin was too strong for the detection of bands due to the compounds being studied, hexachlorbutadiene was used instead[3]. The instrument used was a single-beam infra-red spectrometer fitted with a rock-salt prism. It was very carefully sealed, mainly by means of high-vacuum wax, until the flow of a litre or so of nitrogen through the apparatus from a cylinder of compressed gas was enough to reduce the water-vapour content to a few per cent of the original.

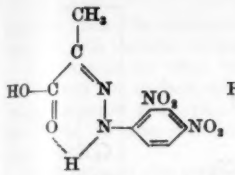
The infra-red spectra were naturally of some complexity. The details of each compound, anthranilic acid, N-2 : 4-dinitrophenylanthranilic acid, 2 : 4-dinitrophenylhydrazine and the 2 : 4-dinitrophenylhydrazones of acetaldehyde, pyruvic acid (1 and 2), α-keto-glutaric acid (1 and 2) and oxalacetic acid (mainly 2) are given semi-diagrammatically in Fig. 1. The height of the vertical lines, which represent absorption bands, is a measure of the intensity of the bands (per cent absorption). The only drawback to this method of presentation is that shoulders on the sides of main absorption bands appear as distinct peaks. However, where this has occurred and it has any bearing on the interpretation of the results, the fact has been indicated in the text.

A brief inspection of the structure of the compounds, assuming them to be geometrical isomers, suggested that interaction might be possible between the carbonyl of the carboxylic acid group and the imino group attached to the aromatic ring. Such interaction might well affect the absorption bands of both the carbonyl group and the imino group. In the present study, attention was focused more particularly on the nature of the absorption arising from the stretching of the carbonyl link, because the bands attributable to this cause are characteristic and occur in a part of the spectrum which is free from interference due to the 2 : 4-dinitrophenylhydrazine residue (compare with the spectra of the free hydrazine and acetaldehyde hydrazone). An additional advantage is that the position of the carbonyl frequency is not appreciably modified by differences in crystalline form. The positions of the absorption bands arising from the stretching of the imino link were obscured by uncertainties in the calibration of the instrument and the relatively poor resolution obtained with the rock-salt prism in this part of the spectrum. The spectrum of each compound will be discussed in turn.

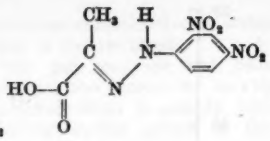
Pyruvic acid 2 : 4-*dinitrophenylhydrazone* (1), R_F 0·6 on paper buffered to *p*H 8·0 (cf. ref. 1), melting point 208° (decomp.), $\lambda_{max.}$ 380 mμ in 0·2 *M* sodium bicarbonate, gives very little red colour with 1–1·5 *N* sodium hydroxide (0·001 *M*).

The compound gives rise to two absorption bands, at 1,722 and 1,672 cm.⁻¹. That both these bands are associated with the carbonyl linkage is borne out by the fact that they disappear in the spectrum of the sodium salt. The presence of a subsidiary band at 1,672 cm.⁻¹ suggests that some form of chelation has taken place in a substantial proportion of the absorbing molecules. Whereas normal saturated aliphatic acids absorb strongly in the region 1,725–1,700 cm.⁻¹ in the solid state, it has been shown by Flett[4] that, in a significant number of cases where chelation can occur between the carbonyl linkage and an amino or imino hydrogen, absorptions occur below 1,680 cm.⁻¹.

In order to supply confirmatory evidence, the spectra of anthranilic acid and its N-2 : 4-dinitrophenyl derivative were obtained. These molecules give rise to single absorptions at 1,667 and 1,679 cm.⁻¹ respectively, from which it may be deduced that chelation is complete. This would be facilitated by the proximity of the carboxyl and amino (or imino) groups. The actual positions of the bands may not be strictly comparable, due to the possibility of conjugation between the carbonyl linkage and the benzene ring. Taking the structure normally assigned to the hydrazones of α-keto-acids, the most likely explanation of the occurrence of the band at 1,672 cm.⁻¹ in the present isomer is that hydrogen bonding occurs between the hydrogen of the imino group



(I)



(II)

of the 2 : 4-dinitrophenylhydrazine residue and the carbonyl oxygen of the carboxyl group (see I).

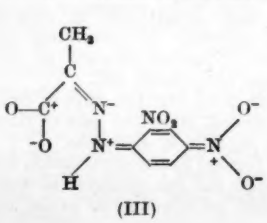
Pyruvic acid 2 : 4-*dinitrophenylhydrazone* (2), R_F 0·4, melting point 210° (decomp.), $\lambda_{max.}$ 370 mμ in 0·2 *M* sodium bicarbonate, gives a characteristic red colour with 1–1·5 *N* sodium hydroxide (0·001 *M*).

The spectrum in the carbonyl region is characterized by the appearance of a strong absorption band at 1,726 cm.$^{-1}$ together with a very weak absorption at 1,676 cm.$^{-1}$. It is highly probable that this absorption arises from contamination with a trace of the other isomer. The absence of a band of any appreciable intensity below 1,680 cm.$^{-1}$ precludes the possibility of any form of chelation in the molecule, and the value (1,726 cm.$^{-1}$) of the carbonyl frequency eliminates the possibility of ring formation with the resulting modification of the carbonyl group. The structure would be represented by (II).

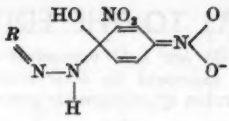
These structures (I and II) are consistent with the other properties of the compounds. The melting point of (I) is slightly lower than (II), though this is scarcely significant because melting points accompanied by decomposition are not very characteristic and in addition there is a marked inter-conversion of such isomers at the melting point[5]. The sodium salts of (I) and (II) will have the same configuration, but without the hydrogen bond between the imino group and the carbonyl group. The higher R_F value of the sodium salt of (I) on paper chromatograms is a reflexion of the steric interference of the neighbouring phenyl group on the ability of the ionized carboxyl to attract water molecules and become incorporated in the water–cellulose complex[6]. Such steric factors are not present in (II). The higher $\lambda_{max.}$ of (I) in the ultra-violet as compared with (II) is probably due to the stabilization of an excited state such as (III), as a result of electrostatic attraction (cf. Ramirez and Kirby[6]).

The deep red colour given by most 2 : 4-dinitrophenylhydrazones of ketones in alkali is probably due to the attack by an OH^- to give a compound such as (IV) (or resonance form). In the case of (I) the approach of the OH^- is hindered by the proximity of the ionized carboxyl group, and little or no red colour is formed. (II) gives the usual red colour.

α-*Keto-glutaric acid* 2 : 4-*dinitrophenylhydrazone* (1), R_F 0·28, melting point 145° (decomp.), $\lambda_{max.}$ 387 mμ in 0·2 *M* sodium bicarbonate, gives a weak red colour with 1–1·5 *N* sodium hydroxide (0·001 *M*).



(III)



(IV)

The spectrum is characterized by the appearance of an intense absorption at 1,707 cm.$^{-1}$ which is flanked by a shoulder at 1,724 cm.$^{-1}$ and a subsidiary peak at 1,673 cm.$^{-1}$. The band at 1,707 cm.$^{-1}$ corresponds to the single band shown by the higher members of the aliphatic dicarboxylic acids series at about 1,700 cm.$^{-1}$. Oxalic and malonic acids give rise to two carbonyl absorptions, but they are anomalous. The other two absorptions, at 1,724 cm.$^{-1}$ and 1,673 cm.$^{-1}$, lie in exactly the same positions as the absorptions of isomer (I) of pyruvic acid. This would seem to indicate a similar type of structure to that postulated for the pyruvic isomer (I).

α-*Keto-glutaric acid* 2 : 4-*dinitrophenylhydrazone* (2), R_F 0·16, melting point 215° (decomp.), $\lambda_{max.}$ 377 mμ in 0·2 *M* sodium bicarbonate, gives a moderately strong red colour with 1–1·5 *N* sodium hydroxide (0·001 *M*).

As in the case of the faster moving derivative, this compound gives rise to an intense band centred at 1,705 cm.$^{-1}$. The shoulder to this band at 1,717 cm.$^{-1}$ and a weaker peak at 1,682 cm.$^{-1}$ point to a lower degree of hydrogen bonding, since they are separated by 35 cm.$^{-1}$ instead of 51 cm.$^{-1}$ as in the faster moving compound. The hydrogen bond is possibly between the carbonyl of the carboxyl farthest away from the hydrazine residue and the imino hydrogen, thus suggesting that an 8-membered ring is present.

The other properties of these compounds agree with the conclusions drawn from the infra-red study. As in the case of pyruvic acid, the *cis* isomer ((I) in the case of pyruvic acid) has the lower melting point, higher $\lambda_{max.}$ and gives a rather weaker red colour with alkali. The red colour of both isomers is weak compared with that of pyruvic acid (II), and this may be ascribed to the effect of the ionized carboxyls near the phenyl group shielding it from attack. The high R_F value of the *cis* isomer in solvents containing large amounts of ammonia may be ascribed to the fact that the free carboxyl in this case is very weak (pK_a about 6, the other has pK_a about 3), and the ammonium salt is largely undissociated and therefore more soluble in organic solvents.

Oxalacetic acid 2 : 4-*dinitrophenylhydrazones*. These were too unstable as the free isomers for detailed examination. $\lambda_{max.}$ of the faster moving isomer as compared with that of the slower ($\lambda_{max.}$ 385 and 370 mμ in 0·2 *M* sodium bicarbonate respectively) suggested by analogy with pyruvic acid that it had the *cis* configuration.

We would like to thank Dr. Mansel Davies for reading the manuscript and Dr. T. Swain for the suggestion regarding the use of hexachlorbutadiene.

The work described in this paper was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research. [Oct. 27

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LETTERS TO THE EDITORS

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Gas-Phase Chromatography

Quite recently, papers have appeared describing in detail the process of gas-phase chromatography[1–5]. Briefly, a sample of gas is injected into one end of a column packed, for example, with kieselguhr impregnated with a high-boiling organic compound such as dinonyl phthalate, and a current of nitrogen is fed into the column to elute the sample. Owing to the fact that various compounds diffuse through the column at different rates, the components of the mixture emerge diluted with nitrogen and can be identified individually. Generally, some physical property of the issuing gas, such as thermal conductivity, is measured, and a continuous record of this property as a function of time is obtained. Each component of the mixture shows up as a separate peak and, from the time taken for it to appear, identification can be made; the size of the peak provides a measure of the concentration. Unfortunately, detectors depending on thermal conductivity vary widely in sensitivity for different gases, and the maximum sensitivity obtainable for many gases is not very high.

To extend the field of usefulness of gas chromatography, the need for a more uniform and more sensitive means of detecting each component as it emerges from the column has become apparent, and the infra-red gas analyser appears to meet these requirements in many cases. For infra-red absorbing gases, it would suffice to use a detector in the instrument sensitive to all the compounds present in the sample; but still the sensitivity to various compounds would vary somewhat, and also adequate sensitivity might be difficult to obtain. In the case of organic gases and vapours, these difficulties are readily overcome by passing each compound as it comes from the column through a tube containing copper oxide heated to dull redness, or other suitable oxidizing agents, to convert the carbon to carbon dioxide and any hydrogen to water vapour. These gases are then passed through an infra-red gas analyser provided with a detector sensitive to carbon dioxide, and as each component emerges from the column and passes into the instrument after oxidation, an indication on the output meter is obtained. This procedure (patent applied for) has the following important advantages.

(1) Very high sensitivity is obtainable, since there is no difficulty in obtaining full scale for 0·01 per cent of carbon dioxide in nitrogen when using a 30-cm. absorption cell.

(2) The gas from the hot copper oxide need not be specially cooled, since the rate of flow is so small that natural cooling is adequate.

(3) Water formed in the combustion may condense or pass through the gas analyser as vapour. Gross amounts should be removed to avoid loss of carbon

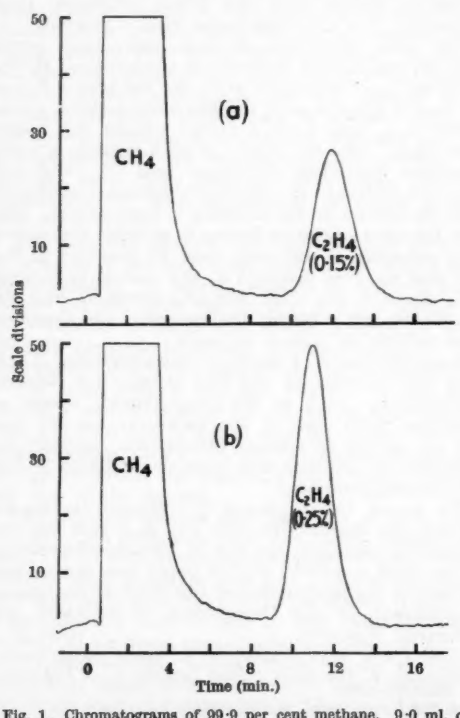

Fig. 1. Chromatograms of 99·9 per cent methane. 9·0 ml. of sample. Nitrogen flow, 30 ml./min. Column temp., 57° C. 10-cm. cell in gas analyser, sensitivity full scale for 0·06 per cent carbon dioxide. (*a*) Original sample. (*b*) Sample with 0·103 per cent ethylene added

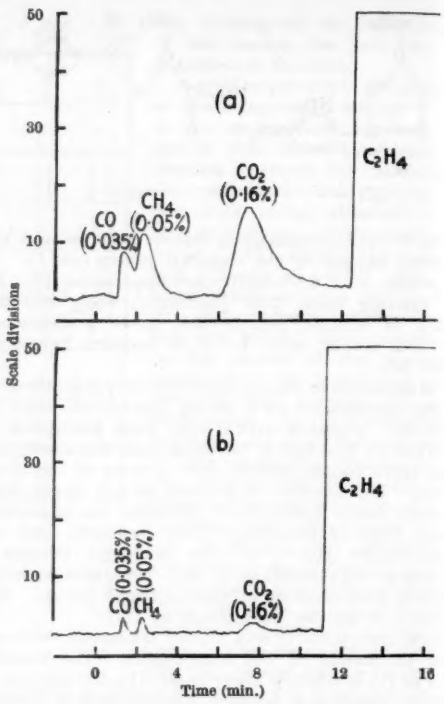

Fig. 2. Chromatograms of cylinder ethylene. 9·0 ml. of sample. Nitrogen flow, 25 ml./min. (*a*) Column temp., 20° C., at start, rising to 45° C. after 3·5 min.; 10-cm. cell in gas analyser, sensitivity full scale for 0·06 per cent carbon dioxide. (*b*) Column temp., 20° C., at start, rising to 45° C. after 2·5 min.; 1-cm. cell in gas analyser, sensitivity full scale for 0·6 per cent carbon dioxide

dioxide; but the instrument is unresponsive to water vapour and careful drying is not required.

(4) Assuming that the gas analyser has been calibrated for carbon dioxide, the sensitivity to any other organic gas after combustion is simply proportional to the number of carbon atoms in the molecule.

To illustrate the power of the method, chromatograms of methane and ethylene were obtained using a column made by packing a 30-cm. length of glass tubing, 4 mm. bore, with activated charcoal[2]. The column was enclosed in a water jacket which could be heated electrically, and nitrogen was allowed to flow through the column continuously at the rate of 25–30 ml./min., a pressure head of 13 cm. mercury being required to maintain this flow. Approximately 10 ml. of sample gas was injected from a gas burette, the flow of nitrogen being interrupted for a few seconds while this was done.

Fig. 1 shows chromatograms of methane (said to be 99·9 per cent pure by the suppliers), with and without the addition of 0·103 per cent by volume of ethylene. No impurity is disclosed in the methane except 0·15 per cent of ethylene. Fig. 2(*a*) shows a chromatogram of ordinary cylinder ethylene; the presence of carbon monoxide, methane and carbon dioxide are clearly indicated. Fig. 2(*b*) was obtained under similar conditions except that the path-length of the sample cell in the gas analyser was reduced from 10 cm. to 1 cm. This has the effect of reducing the sensitivity to a considerable extent, but discrimination is improved, and the carbon monoxide and methane peaks are clearly separated. Higher hydrocarbons are well displaced from the ethylene peak, but were not present to any appreciable extent in the two gases tested.

There is an optimum length of absorption cell in the infra-red gas analyser for each compound, depending on the time taken to remove it from the column. For maximum sensitivity, the volume of the sample cell should equal approximately the total volume of nitrogen required to sweep the gas in question from the column; a longer cell merely broadens the band without increasing its height.

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Permanent Dissociation of Sulphur Hexafluoride in Corona Discharges

The high dielectric strength of sulphur hexafluoride has been measured by various workers, and many reasons for its existence have been put forward. Because of its good insulating properties, sulphur hexafluoride is now used extensively in Van de Graaff generators and in gas-filled cables. The following experiments were carried out to find what permanent changes in molecular pattern, if any, could be observed when a corona discharge was run in sulphur hexafluoride and the products examined with a mass spectrometer. Clearly the results would be of interest in practical cases where corona discharges are present.

Table 1

Ion	Relative abundance	Ion	Relative abundance
SF_5^+	100	SF_3^+	3·4
SF_4^+	9·3	SF^+	3·3
SF_3^+	22·8	F^+	1·3

There appear to be no published mass spectrometer studies of the permanent products of dissociation in electrical discharges in complex-attaching gases. Schumb, Trump and Priest[1] passed corona and spark discharges through sulphur hexafluoride, noted pressure changes, as previous workers had done, and showed that potassium hydroxide solution dissolved some of, but not all, the dissociation products. It was suggested that the insoluble gases were lower fluorides such as SF_4, SF_2 or S_2F_2. The pressure of sulphur hexafluoride was slightly greater than atmospheric, and corona discharge ran for periods of 50–200 hr. with currents in the range 50–200 microamp.

The relative abundances of the positive ions formed by electron bombardment in sulphur hexafluoride were determined using a 60° Nier-type mass spectrometer. The sulphur hexafluoride, at a pressure of about half an atmosphere, was contained in a small glass discharge tube (30 c.c. capacity) with point–point tungsten electrodes, the gap spacing being 1·3 cm. The relative abundances were determined over a period of days for the same sample (Table 1); small beams of O_2^+, N_2^+, Hg^+, Hg^{++} and H_2O^+ were also present.

The changes in abundance of the ion species were investigated for three different values of discharge current. No attempt was made to calculate accurately these currents, nor to have the same conditions of pressure throughout the three trials, as it must be stressed that the investigations were made to find in a preliminary sense the changes taking place due to the discharge, rather than attempting an accurate quantitative investigation. After each of the three trial runs, the tube was thoroughly cleaned with a hot concentrated solution of sodium hydroxide to remove the silicates formed as a result of the discharge. The first discharge was run at 0·40 m.amp. (pulse frequency ~ 1/sec.) for 15 min. No appreciable change was observed in the abundances given in Table 1.

The second discharge was run at ~ 60 m.amp. (frequency ~ 1/sec.) for two hours. Mass spectrometer investigations showed that no SF_5^+, SF_4^+, SF_3^+, SF_2^+ or SF^+ were present, but that there was an increase in the intensity of the F^+ beam, and beams due to SiF_4^+, SiF_3^+, SO_2^+ were observed together with other beams of as yet unidentified ions.

The third discharge was run at ~ 10 m.amp. (frequency ~ 1/sec.) for 30 min. Beams due to SF_5^+, SF_4^+, SF_3^+, SF_2^+ and F^+ were observed, together with those found in the second run. Several measurements of relative abundances were made and the mean values of these determinations and those for the undischarged sulphur hexafluoride are compared in Table 2.

Table 2

Ion	Relative abundance	
	Before discharge	After discharge
SF_5^+	100	100
SF_4^+	9·3	9·5
SF_3^+	22·8	24
SF_2^+	3·4	28
F^+	1·3	400–1,000

From these experiments, it is seen that under certain discharge conditions a change in the ion species of sulphur hexafluoride is observed, as would indeed be expected. Although no attempt has been made to carry out a rigorous investigation, we have established the fact that appreciable permanent molecular dissociation accompanies the discharge, as shown by the increase in the F^+ abundance in runs 2 and 3. This increase in F^+ is to be expected, as the final products should clearly be sulphur and fluorine, but the completeness and speed of the reactions leading to the formation of fluorine are surprising.

The increase in the abundance of SF_3^+ is unexpected, as it would be thought more likely that the intermediate changes in the reaction $SF_6 \rightarrow S + 6F$ would involve changes in the relative abundances of SF_5^+, SF_4^+ and SF_3^+.

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Nov. 11.

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A Molecular Approach to the Problem of Viscoelasticity

As a first step, the type of material considered is that coming under the generic heads of 'paper' and 'board'. These materials are made of cellulosic fibres which are filtered off as sheets from liquid suspensions and dried to give the final product. The bonds between the fibres are almost entirely made up of hydrogen bridges between cellulosic and hemicellulosic components.

The rheological curve obtained may be represented by Fig. 1. The material has all the usual time-effects of viscoelasticity. Under constant load it creeps, and under constant extension it relaxes; consequently it shows hysteresis, and the stress/strain curve is dependent on the rate of application of load or the rate of stretching.

Fig. 1. Stress-strain behaviour of paper

The theory proposed here is that when such a material is strained by $(\delta\sigma)$, showing a stress, f, the energy input $(f\delta\sigma)$ simply goes to raise the hydrogen bond potential from $-U_o$ at equilibrium to $(U = -U_o + \delta U)$. Taking infinitesimal quantities, then,

$$f = \mathrm{d}U/\mathrm{d}\sigma. \qquad (1)$$

It only remains to select a function $U(\sigma)$ to evaluate (1). The Morse[1] function, rearranged from its usual form, is:

$$U = U_o\,[\exp(-2a\sigma) - 2\exp(-a\sigma)]. \qquad (2)$$

Thus, differentiating and expanding (2) gives:

$$f = 2a^2 U_o\left[\sigma - \frac{3}{2}a\sigma^2 + \frac{7}{6}a^2\sigma^3 - - -\right] \qquad (3)$$

$$= E\sigma - K\sigma^2 + - - - -,$$

where $E = 2a^2U_o$ and $K = 3a^3U_o$. In these equations U_o is in units of energy per unit volume, not per mole.

Equation (3) not only fits the curves obtained for these viscoelastic materials well, but also has the merit of depending on two parameters both of which should be, in principle, deducible from non-rheological data. Thus a can be evaluated rheologically as $(2K/3E)$ or spectroscopically from the infra-red absorption of cellulose. Rheological data give $a = 16{\cdot}8 \pm 3$, whereas spectroscopy yields $a = 19{\cdot}4 \pm 2$. The agreement may be considered as not unsatisfactory. Physically a is connected with that compressional strain σ^* which is necessary to raise the hydrogen bridge potential from $-U_o$ to zero, by $a = (\ln 2/\sigma^*)$. Similarly, U_o is connected with the molar heat of dissociation of the hydrogen bond φ_o by $[U_o/\varphi_o] = R$, where R is the number of moles of hydrogen bonds per cm.^{3} of tested material which are subjected to strain.

According to this theory, time-effects are due to the fact that since the hydrogen bond is a weak link it breaks under strain. Thus R continually decreases with time and the problem resolves itself into a problem of chemical kinetics. Re-formation of the weak bonds gives rise to certain appearances of hardening under some conditions.

The choice of the Morse function for the bond potential is somewhat arbitrary; other functions have just as much justification. It is a very convenient function for the purpose; but it suffers from one drawback. This function gives a maximum for f at a strain $\sigma = (\ln 2/a)$. Thus it cannot be applied for materials with $a \sim 20$ beyond a strain of 0·03 or thereabouts. For paper and board this is immaterial, as they normally break at lower strains; for other cellulosic materials this fact sets a limitation on the theory and equations. Cotton yarn, for example, does not yield such useful results as paper and board; probably other functions are required.

I am indebted to Dr. L. Peters, of this Department, for many discussions and for the suggestion to use the Morse function. It is hoped to publish a more detailed treatment of this theory elsewhere.

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Nov. 8.

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Infra-red Absorption Spectrum of Fluoropyruvic Acid

Mager and Blank[1] have reported the synthesis of fluoropyruvic acid and claim that its infra-red spectrum shows an absorption band at 980 cm.$^{-1}$, which they assign to the C—F stretching vibration. This frequency is outside the range normally assigned to this vibration[2], and differs markedly from that suggested[3] and afterwards found[4] for this vibration in fluorocitric acid.

An opportunity has recently occurred to examine a sample of fluoropyruvic acid synthesized by the

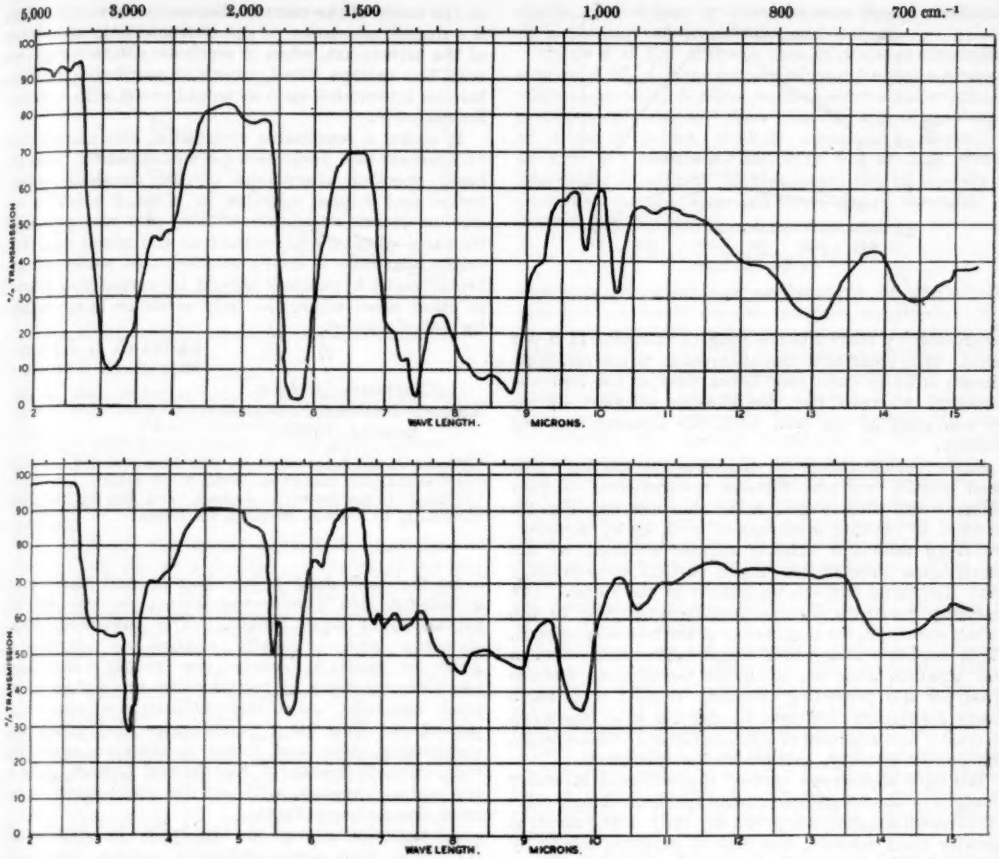

Fig. 1. Upper spectrum, pyruvic acid; lower spectrum, fluoropyruvic acid

route described[1], and the infra-red absorption spectrum of the compound has been examined. Comparison of its spectrum (Fig. 1, lower) with that of pyruvic acid (Fig. 1, upper) suggests that the band which should be assigned to the C—F stretching vibration occurs at 1,022 cm.$^{-1}$. This is within the accepted frequency-range for this vibration and is in close agreement with the frequency of the corresponding band (1,026 cm.$^{-1}$) in the barium salt of fluorocitric acid. The absence of a band at the claimed frequency of 980 cm.$^{-1}$, and the observation that the wave-length of the observed band is 9·78 μ, suggest that the previous authors may have inadvertently quoted wave-length as wave-number.

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Porton.
Nov. 9.

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Formation of Aquo Ions

In two publications on this general topic, Bjerrum and Jørgensen[1], and Jørgensen[2], have reported on the absorption spectra in ethanol–water mixtures of cobaltous nitrate, among other salts. They conclude from their results that the spectral changes observed are due primarily to exchange between alcohol and water groups on the cation. They suggest in particular[1,2] that the conclusions of Katzin and Gebert[3], based on studies with varied solvents and experimental conditions, to the effect that the spectral changes between water solution and solutions in organic solvents are due primarily to cation–anion complex interaction are therefore in error.

The implication of the Bjerrum–Jørgensen interpretation is that the spectral effects discussed should be independent of the anion, when dealing with anions no more strongly complexing than nitrate ion. In particular, it would be expected that cobaltous perchlorate should show the same effects, since perchlorate is notoriously a poor complexing anion.

Fig. 1 shows curves of optical density (1 cm. path-length) against wave-length for (*a*) aqueous cobaltous nitrate, (*b*) cobaltous nitrate in ethanol, and (*c*) cobaltous perchlorate in ethanol. All three refer to the same concentration of cobalt (0·0199 *M*), and the two alcoholic solutions have the same water con-

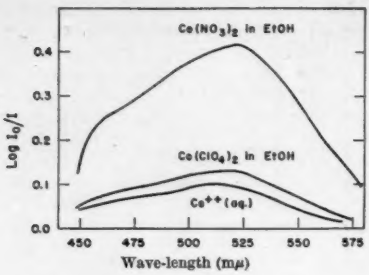

Fig. 1

centration by Karl Fischer reagent titration (1·3 per cent). It is clear that the absorption of the alcoholic nitrate is more than four times that of the aqueous solution, whereas the perchlorate solution differs by less than 30 per cent from the aqueous spectral density.

Since measurements on nickelous nitrate have also been cited[2], we can furnish comparisons of perchlorate and nitrate spectra for this case too (Fig. 2). Instead of making solutions of both salts, however, we have added a lithium nitrate solution to the perchlorate solution, to make certain conveniently that the metal ion concentration is the same. The intensity relations are completely analogous to the cobalt situation, for both peaks of the nickel spectrum. With copper[2], there is a bigger difference between the aqueous and the alcoholic perchlorate spectra than for the preceding (possibly related to a more ready formation of copper complexes with univalent anions); but addition of lithium nitrate still increases the optical density, and shifts the spectrum.

We have also shown earlier[3] that shifts or intensity changes of the cobaltous nitrate spectrum larger than for ethanol solution are given not only in the alcohols heavier than ethanol, but also in acetone, which by all criteria is recognized as a weaker electron donor than the alcohols. Finally, it has also been shown

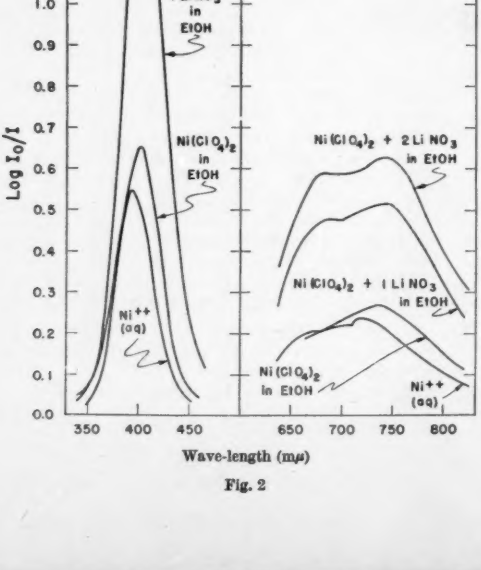

Fig. 2

in the cases of the nitrates discussed above that there is a drastic alteration of the characteristic absorption of the nitrate ion, when in alcoholic solution together with the cations listed, which is ascribable to some intense interaction such as would occur with complex formation[3,4].

It seems a reasonable conclusion, the calculations of Bjerrum and Jørgensen notwithstanding, that the basic spectral alterations of the divalent cobalt, nickel and copper nitrates in ethanol solution are due to cation–anion interaction, and not primarily to water–alcohol replacement on the metal ion. One might also raise a doubt whether this water–alcohol replacement hypothesis should be considered proved in other cases where the only evidence is agreement by calculation[1,2].

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In the preceding letter, Katzin and Gebert are criticizing the conclusions drawn by us on the formation of aquo ions[1,2]. The transition group elements were originally studied as nitrates in alcoholic solution, since the nearly anhydrous alcoholic solutions of perchlorates are liable to explode violently. After the publication of the second paper[2], we have used perchlorates and other non-complexing salts and found qualitative agreement with the new results of Katzin and Gebert. We do not agree, however, with all the conclusions drawn from these observations.

At the maximum of the absorption band of cobalt(II) salts with non-complexing anions, the molar extinction coefficients ε are about 60 per cent higher in nearly anhydrous ethanol than in water, and not 30 per cent as measured by Katzin and Gebert in 0·7 *M* water solution. Since cobalt(II) perchlorate, *p*-toluenesulphonate and trifluoroacetate all show the same spectra in ethanol and the same changes on addition of small quantities of water, it is most probable that these changes correspond to the real exchange of ethanol with water in the hexa-solvatized cobalt(II) ion, while we recognize that anion effects are superposed on the solvation effect by the much larger change in cobalt(II) nitrate solutions. Fig. 1 shows that cobalt(II) *p*-toluene-sulphonate has its mid-point of change by addition of water (in our opinion the average formation of $Co(H_2O)_3(C_2H_6OH)_3^{++}$) at a water concentration of about 2·0 *M* at 25° C., and the corresponding value for the nitrate is 0·92 *M* [2].

The strongly coloured compound in nearly anhydrous solutions of cobalt(II) nitrate is presumably not an electrostatic associate with the nitrate ion outside the solvation shell. Recently, the crystal field-theory has been applied to the absorption spectra of the transition group ions[3,4]. It is improbable that long-range effects will be observable in the spectra, and nitrato-complexes usually have their bands at slightly shorter wave-lengths than the corresponding aquo ions. Experimentally, the electrostatic associates, which undoubtedly exist in cobalt nitrate solutions in carbon tetrachloride with

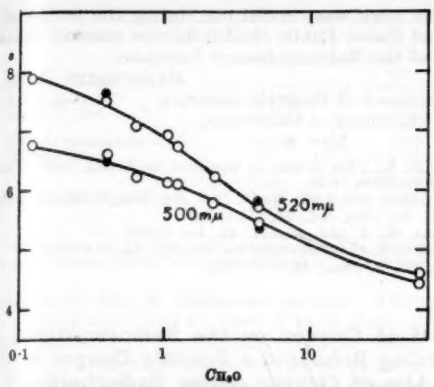

Fig. 1. Molar extinction coefficient of cobalt(II) *p*-toluenesulphonate at 520 and 500 mμ as a function of the water concentration C_{H_2O} on a logarithmic scale.

C_{Co} = 0·006 *M* (open circles) and 0·06 *M* (filled circles)

some water and ethanol, have been found[2] to have nearly the same spectrum as the pure aqueous solutions.

Fig. 2 shows the molar extinction coefficient of cobalt at 520 mμ as a function of the ratio between ammonium nitrate and cobalt, $C_{NO_3^-}/C_{Co}$ at different concentrations of cobalt(II) *p*-toluenesulphonate and water. (Measurements carried out at 500 and 480 mμ give analogous results.) It is seen from the slope of curve 1 that a mono-nitrato complex is formed with so large a formation constant (> 200) that dilution to 0·006 *M* cobalt has not much influence on the steep increase of ε caused by the nitrate first added at low concentrations of water. At larger values of $C_{NO_3^-}/C_{Co}$ there seems to be some difference at the same water concentrations, but the activity corrections for variable salt concentrations are difficult to estimate. It is not certain that a di-nitrato complex is formed to any great extent, and the formation is at least far from complete at $C_{NO_3^-}/C_{Co} \sim 2$, as is also shown by the conductivity of cobalt(II)nitrate in ethanol[1]. In the higher alcohols and ketones di-nitrato complexes are more

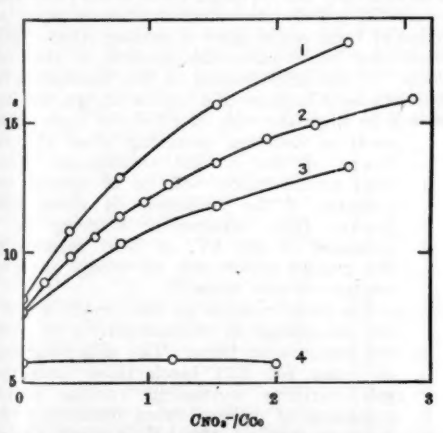

Fig. 2. Molar extinction coefficient of cobalt at 520 mμ as a function of the ratio between the concentration of ammonium nitrate and of cobalt *p*-toluenesulphonate.

Curve 1, C_{Co} = 0·006 *M*, C_{H_2O} = 0·08 *M*; curve 2, C_{Co} = 0·06 *M*, C_{H_2O} = 0·43 *M*; curve 3, C_{Co} = 0·006 *M*, C_{H_2O} = 0·43 *M*; curve 4, C_{Co} = 0·06 *M*, C_{H_2O} = 4·0 *M*

stable, and colour is more intense than in ethanol, as is pointed out by Katzin and Gebert.

Curve 4 of Fig. 2 shows that at a water concentration of 4 *M*, a large excess of ammonium nitrate is without perceptible effect on the spectrum of cobalt(II) *p*-toluenesulphonate. Also ε at 520 mμ of a solution of 0·006 *M* cobalt, 0·36 *M* ammonium nitrate, is 23·4 at 0·1 *M* water, but only 6·2 at 4 *M* water. The order of affinity to the metal ion of ligands is, according to the term 'electron donor strength' of Katzin and Gebert:

$$H_2O > NO_3^- > C_2H_5OH$$

which is a reasonable explanation of the strong influence of water on the complex equilibria. But since water is only eight times more strongly bound than ethanol[2] to cobalt(II) *p*-toluenesulphonate (where formation of anion complexes can scarcely be the explanation of the spectral change at a relatively large water concentration compared with the case of nitrate), the special tendency of the ethanol-solvatized cobalt ion to take up nitrate ions is peculiar. Perhaps steric reasons are responsible for the easy removal of one or two of the alcohol molecules, while the hexa-aquo ion is more stable towards uptake of nitrate ions. The stability of the nitrato-complex increases with the temperature. This can be observed qualitatively in boiling ethanol, where the persistence of the strong colour on addition of water is remarkable.

The nitrate ion has not such a disturbing influence in all of the cases investigated. Bis(ethylenediamine)-copper(II) ions do not seem to show anion effects, since the perchlorate, the nitrate and the chloride have the same spectra in pyridine, which has a lower dielectric constant than ethanol and is bound more weakly than water to Cu en_2^{++}. The spectra of this ion in water, methanol, ethanol and pyridine are all different, showing no common non-solvatized form.

The suspicion thrown on solvation phenomena in general cannot be justified in the case of inner-complex salts without anions. As will be shown later, nickel(II)bis(acetylacetonate) in benzene shows distinct changes of absorption spectrum by addition of ethanol (water precipitates the dihydrate), and nickel-(II)bis(formylcamphor)ethylenediimine in benzene is solvated by methanol.

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Ranges of Low-Energy Electrons in Protein

A knowledge of the effective range of low-energy electrons in protein is of considerable biological interest. The ranges as calculated by Lea[1] from the Bethe theory of energy-loss cannot be accepted without experimental verification, since the validity of the assumptions made in the computations are questionable at the low energies. The sensitivity of small biologically active molecules to radiation can

be used to measure the ranges by employing a layer of enzyme of thickness greater than the range of the electrons as an absorber. If a thin, uniform layer of dry enzyme is irradiated with a sufficiently large number of electrons, all the enzyme within the range of electrons is inactivated. After irradiation, the enzyme is assayed for remaining activity; knowing the amount inactivated, the surface area irradiated and the density of the material (taken as 1·3 gm./c.c.)[2] the range of the electrons in the enzyme can be found. Irradiations using the enzyme invertase[3] have already been carried out, and the ranges found were significantly less than those calculated by Lea. The size of the enzyme molecule itself prevented any measurements being made at energies less than 600 eV., for at that energy a layer one enzyme molecule in thickness was inactivated. The inaccuracies of the assay made the determinations at energies greater than 1,500 eV. uncertain.

These measurements have now been extended using deoxyribonuclease; the enzyme as well as the deoxyribonucleic acid for the assay were supplied by Worthington Biochemicals, Inc.; the assay was that of Kunitz[4]. Due to the smaller size of the molecule, accurate determinations of the ranges could be made down to energies of 300 eV. At energies smaller than this, the observed range became constant at a value of 60 A., corresponding to a layer one molecular diameter in thickness (see Fig. 1). High-energy radiation studies on deoxyribonuclease[5] have shown it to have a molecular weight of 62,000, and it is thought to be spherical with a diameter of 56 A. Between 300 and 1,500 eV., the range measurements agree remarkably well with those made using invertase. Above 1,500 eV., the ranges are in general somewhat lower than those given by the invertase measurements, showing a greater discrepancy from the theoretical curve.

The work of Alper[6] on the ranges of electrons in air, when corrected for the differences in density and stopping power between air and protein, also shows the experimentally determined ranges to be less than the theoretical values in the low-energy region. The quantum mechanical treatment of energy-loss is expected to break down when the velocity of the incident electron is such that the electron spends a finite length of time in the field of the absorber atom and therefore suffers one or more collisions. The experimental values are therefore more nearly correct for the ranges of low-energy electrons (delta-rays being of considerable interest) than those obtained by extrapolation of the curve valid at high energies.

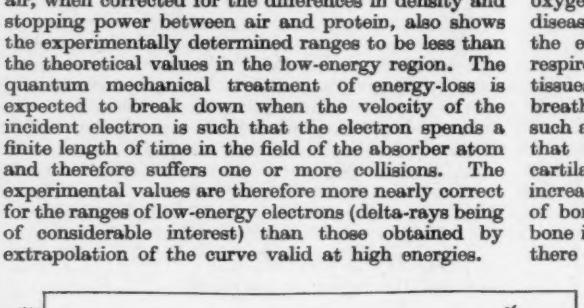

Fig. 1. ——, Theoretical curve; ----, experimental curve; ×, deoxyribonuclease; ⊙, invertase

This work was carried out during the tenure of a United States Public Health Service research fellowship of the National Cancer Institute.

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Effect of Oxygen on the Radiosensitivity of Growing Bone and a Possible Danger in the Use of Oxygen during Radiotherapy

That oxygen tension has an effect on the radiosensitivity of living tissue has been known for many years, and the subject has been recently reviewed[1]. The effect was studied by Read[2], who established the form of the curve relating oxygen tension and radiosensitivity for a plant tissue. An essentially similar relation has been shown to hold for a wide variety of plant and insect tissues, though comparable data on mammalian tissue is still far from complete. The effect of partial anoxia on the lethal dose of whole-body irradiation has been investigated[3]; but we are not aware of quantitative data on radiosensitivity at a variety of partial pressures of oxygen for either the local irradiation of tissue in the intact animal or whole-body irradiation.

The possibility that increasing the partial pressure of oxygen in the respired gas might improve the radiosensitivity of tumours differentially in comparison with surrounding normal tissue[4] has encouraged radiotherapists at a number of centres to administer oxygen to patients during radiotherapy for malignant disease. It has therefore become important to assess the effect of varying oxygen tension in the gas respired by mammals on the radiosensitivity of their tissues. While the change in radiosensitivity on breathing pure oxygen of a well-oxygenated tissue such as skin may not be large, there is the possibility that certain poorly vascularized tissues such as cartilage or bone might show a greater effect. This increase may be of particular concern in the case of bone. If the effectiveness of the irradiation on bone is increased because of a higher oxygen tension, there will be a greater risk of effects of high doses, such as necrosis, occurring after the delivery of the normal therapeutic dose[4]. This consideration will be of special importance if the treatment is given with X-rays from equipment working at a potential of 500 kV. or less, because of the greater absorption of energy in bone relative to soft tissue[5].

For these reasons we have made a study of the change of radiosensitivity of growing mammalian bone. The tails of groups of 7-day old *C57* black mice, breathing gas mixtures containing various partial pressures of oxygen, were irradiated with a single dose of 190 kV. X-rays. When anoxia of tissues was required, a cuff was fitted over the tail and a pressure of 280 mm. mercury applied. Three weeks later, the growth of the irradiated tails was com-

Table 1

	Anoxia	Partial pressure of respired oxygen (atmospheres)				
		0·1	0·2	0·4	1	3
Radiosensitivity* Standard error	0·0734 ± 0·0025	0·097 ± 0·006	0·145 ± 0·005	0·166 ± 0·009	0·188 ± 0·010	0·196 ± 0·009
Relative radiosensitivity Standard error	1·00 —	1·32 ± 0·10	1·97 ± 0·10	2·27 ± 0·15	2·56 ± 0·16	2·67 ± 0·13
Doses used (roentgens)	1,500 2,000 3,000	1,500 2,000	500 1,000 1,500	375 750 1,000	375 750 1,000	375 750 1,000

* ($\log_{10}$ control growth − $\log_{10}$ irradiated growth, mm.)/dose K roentgens. This formula is used to calculate the radiosensitivity because the curve relating growth with dose appeared to be more nearly exponential than linear.

pared with that of litter-mate controls. Groups of six animals were used for each of three doses at each partial pressure of oxygen (except 10 per cent). The results of these experiments are given in Table 1.

The increase of radiosensitivity observed on changing the respired gas from air to oxygen at one atmosphere was 1·30 ± 0·06. Whether this factor applies to other tissues in mice or to analogous tissues in man remains to be seen. However, the results presented here suggest that there may be danger in giving the same dose to a patient breathing oxygen that is normally given when breathing air. We hope to report the results more fully elsewhere.

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Relation of Magnesium Supply to Growth and Net Assimilation-rate in Barley

In recent years attention has been directed to the increasing incidence of magnesium deficiency in crop plants[1], and it is also possible that such a deficiency may cause disease in ruminants grazing on affected herbage[2]. Using the methods of growth analysis[3], a study is being made of the effect of this element on carbon assimilation in plants.

Barley plants (var. Plumage Archer) were grown in an unheated greenhouse in unaerated water cultures at eleven magnesium concentrations, varying from 0 to 300 p.p.m. Magnesium was added as $MgSO_4 7H_2O$, the concentration of the sulphate radical being kept constant over the range of 0–100 p.p.m. of magnesium, by the addition of sodium sulphate. No sodium sulphate was added to the 300 p.p.m. solution. Each treatment was replicated four times. 300-ml. soda glass jars were used, and three plants were grown in each. The solutions were changed weekly and the *p*H adjusted to 6·0.

The seed was sown in sand on March 26, 1954, and the seedlings transferred to water culture on April 8. Leaf areas and dry weights of whole plants were determined on April 8 and after 24 days growth in water culture. Leaf areas were calculated using a leaf-index method[4]. At the end of the experiment the total magnesium content of the leaves was determined by the method of Mason[5].

Where the magnesium supply limited growth, some leaves died before the final sampling and others were completely chlorotic. Thus it seemed possible that differences between the net assimilation-rate of magnesium-deficient and normal plants might be due in part to the increased rate of senescence of the leaves of the former. In order to minimize this effect, the leaf areas of withered leaves at the final sampling date were not included in the final leaf areas. Their dry weights were, however, included in the final dry weights. This procedure was necessary for plants growing in solutions of magnesium concentration 0–1·23 p.p.m. Thus the net assimilation-rate calculated for these plants will have been overestimated, since leaves dead at the final sampling date will have been actively assimilating at some time during the experiment. An abbreviated summary of the results is presented in Table 1, and graphically in Fig. 1.

Thus an increase in the concentration of magnesium in the nutrient solution from 0·41 to 3·7 p.p.m. resulted in a large and significant ($P < 0.001$) increase in net assimilation-rate and total dry weight. The magnesium concentration in the leaves of these plants increased from 0·07 to 0·12 per cent. This also is a significant increase ($P < 0.001$) when the angular conversions of these values are statistically analysed. The net assimilation-rate did not vary significantly in plants in which the foliar concentration of magnesium ranged from 0·12 to 0·57 per cent.

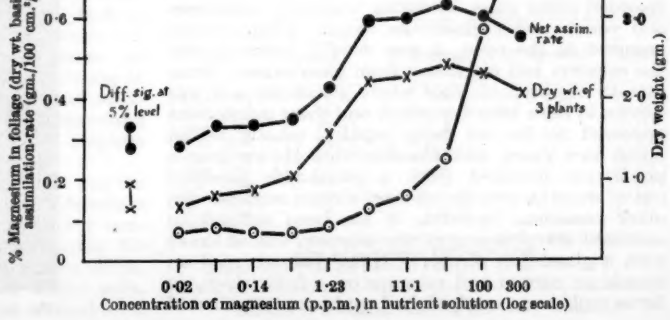

Table 1

Treatment	III	V	VI	VII	VIII	X	XI	Diff. sign. at 5 per cent level
Magnesium in nutrient sol. (p.p.m.)	0·05	0·41	1·23	3·7	11·1	100	300	
Final dry weight of 3 plants (gm.)	0·80	1·05	1·57	2·20	2·27	2·31	2·09	0·23
Net assimilation-rate (gm./100 cm.²/week)	0·33	0·35	0·42	0·59	0·59	0·60	0·55	0·05
Per cent magnesium in leaves (dry matter basis)	0·08	0·07	0·08	0·12	0·16	0·57	0·81	*

* An analysis of variance of the angular conversions of these values indicates that a significant difference ($P < 0·05$) exists between all treatments except between III, V and VI.

The coefficient of variability for net assimilation-rate data in this experiment was 7·14 per cent.

It is tentatively concluded that the 'critical concentration'[6] of magnesium in young barley leaves is approximately 0·12 per cent. Below this value, both total dry matter accumulation and net assimilation-rate are reduced. This work is being reported fully elsewhere.

Acknowledgments are made to the Central Research Fund of the University of London for a grant in aid of equipment and to Dr. I. W. Selman for advice.

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Occurrence of the Root-knot Eelworm, *Meloidogyne hapla*, out of doors in Great Britain

Until recently, only one species of root-knot eelworm was recognized, namely, *Heterodera marioni* (Cornu). Renewed interest has been stimulated with the transfer of the eelworm to the genus *Meloidogyne* and the erection of a number of species[1]. In Great Britain, infestations of root-knot are most often recorded under glass, attacking tomatoes, cucumbers and various other glasshouse crops. When attacks occurred in the open, it was usually assumed that the eelworm had originated from glasshouses. Some attacks occurred on sites where glasshouse soil was known to have been deposited, and these infestations appeared to die out fairly rapidly, usually within about two years, and Franklin[2] has shown that a population obtained from a glasshouse persisted out of doors in pots for at least sixteen months. On other occasions, however, it has been difficult to associate the presence of the eelworm out of doors with a glasshouse source. Triffitt[3] has recorded an attack on carrots and parsnips on a field which, so far as could be ascertained, had not been contaminated with soil from glasshouses. Since 1931 there has been a number of other records (*in litt.*) of attacks in the open on various crops including carrots, parsnips, pyrethrums and scabious, but there must always be some doubt as to whether the eelworm had come from glasshouses.

During the past three years, a number of severe attacks have occurred on various crops in several fields in the eastern counties of England. Here there was no possibility of contamination with glasshouse soil, and it was clear that these attacks were being caused by a species of *Meloidogyne* which thrived out of doors. The symptoms caused were quite distinct from those seen on glasshouse plants, the most striking difference being in the size of the galls. Plants attacked by the species in glasshouses develop large galls with little or no root proliferation, whereas the galls from the outdoor attacks were small, usually not more than 3–4 mm. in diameter and often much smaller still, and on many hosts there was a large amount of root proliferation. It is probable that the attack recorded by Triffitt was caused by the same species, as she also comments on the small size of the galls.

In the United States, of the species recognized at the moment, only *Meloidogyne hapla* can be identified by the type of galling produced on the plant. Plants attacked by this species develop symptoms similar to those described above for the outdoor attacks in the eastern counties of England, and it was considered most likely that this eelworm was identical with *M. hapla*. Confirmation of this has now been obtained from Mr. A. L. Taylor, Section of Nematology, U.S. Department of Agriculture, and it seems reasonable to assume that many of the earlier records also relate to this species, which has probably been long established in Great Britain.

Severe damage has been caused to scabious (*Scabiosa caucasica*) on three fields on light sandy soil in the Mildenhall area of Suffolk. Well-established plants were being killed out by the eelworm. The galls were very small, and there was extensive root proliferation. There have been complete failures of carrots, mangolds, sugar beet and kale on two fields in the Norfolk breckland, and light attacks on several other fields in the same area. On these plants the galls were also small; but the root proliferation

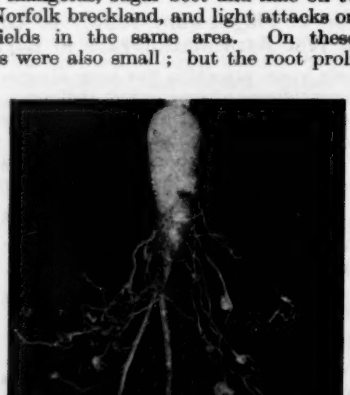

Fig. 1. Carrot attacked by root-knot eelworm

was not so extensive as on the scabious. Cereals are apparently immune from attack. This area also is very light sandy soil. A large number of weed species has been examined on some of these fields, and many of these are hosts.

Thanks are due to Mr. N. D. N. Welford, who has given considerable assistance with the field-work, and to Mr. W. E. Dant for the photograph of the attacked carrot. Investigations into the host-range of this nematode are continuing, and full results will be published elsewhere.

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Witchweed and Soil Fertility

Jones[1] has recently directed attention to a problem of considerable importance in African agriculture, namely, whether *Striga hermontheca* Benth. infestation is only serious on 'worn-out' soils or whether the 'wearing-out' is due to *Striga* itself.

An agricultural survey carried out in the southern Sudan has shown that, while on comparatively poor lateritic soils *Striga* is practically absent, it causes yield reductions of up to 70 per cent on rich alluvial clays. The reason for this seems simple; on the lateritic soils, soil nutrient exhaustion, due largely to erosion of the uppermost layer where nutrients accumulate under bush fallow, forces the native cultivator to abandon the field after a period of from three to five years, before *Striga* infestation can become serious. Moreover, in the areas where these soils occur, good drainage and comparatively high rainfall permit diversified cropping. On the other hand, alluvial clay soils occur in the southern Sudan in areas of marginal rainfall and marginal drainage. *Sorghum*, which can tolerate both drought and, to a lesser extent, water-logging, is in these areas the only crop of major importance. Its cultivation is concentrated on sites less liable to flooding, and on such sites intensive and prolonged mono-cropping with *Sorghum* leads to increasing *Striga* infestation, in time causing serious deterioration of yields. Where better drained land is more plentiful and shifting cultivation possible, *Striga* is regarded by the native cultivator as the main reason for abandoning old fields (usually after six to eight years).

Experiments carried out on heavy alluvial soils at Malakal[2] showed no significant response of *Sorghum* yields to application of fertilizers on recently abandoned 'worn-out' land. The comparison of yields of crops not parasitized by *Striga* grown on 'worn-out' land and newly opened-up land also shows no significant difference. On the other hand, owing to depredations of insect pests (mainly *Sorghum* stem-borer, *Sesamia cretica* Led.), measures controlling *Striga* infestation resulted in no response in *Sorghum* yields.

Conclusions from the above observations can be summarized as follows: (i) *Striga* infestation assumes considerable importance as a factor controlling yields in areas where sites suitable for cultivation, as well as the range of suitable crops, are limited. (ii) On inherently fertile heavy soils, damage due to this parasite reaches the critical level before the appearance of signs of soil exhaustion. (iii) *Striga* is only one of the evils of intensive and prolonged mono-cropping. Its control, for example by selective herbicides, can provide only a partial solution to the problem of *Sorghum* yield deterioration.

Though, in the southern Sudan, soil erosion is generally not serious on the clay plains, owing to lack of slope, on their margins where the slopes are greater, *Striga*, being one of the factors necessitating shifting cultivation, undoubtedly plays an important part in soil conservation. The introduction of an easy method of eradication might, in those areas, lead to over-cultivation and accelerated erosion, which would cause much greater and more permanent damage than the parasite itself.

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Oct. 5.

[1] Jones, K. W., *Nature*, **172**, 128 (1953).
[2] Jonglei Investigation Team: "Equatorial Nile Project and its Effects in the Sudan", **3**, 991 (1954).

A Nematode Parasite of *Drosophila*

Adults of *Drosophila* spp. trapped at frequent intervals in Nature at Dalkeith, Midlothian, were dissected to follow the development of the ovaries, and occasionally the testes, during autumn, winter and spring. The flies dissected were *D. subobscura* Coll. (19 males, 338 females), *D. obscura* Fln. (17 males, 92 females), *D. silvestris* Bas. (41 males, 34 females), *D. tristis* Fln. (2 males, 7 females), *D. funebris* (Fabr.) (3 males, 11 females), and *D. cameraria* Hal. (3 females). During these dissections a few specimens of the first three species were observed to be infested with a nematode, provisionally identified as *Aphelenchulus* sp. (Allantonematidae Chtw. and Chtw., 1937), probably new. The numbers of dissected flies are shown in Table 1, the figures in parentheses being the numbers of those infested.

Over the whole period of eight and a half months, 603 specimens of *Drosophila* spp. were dissected. There were 541 (+ ?36) specimens of the three infested species, of which 18(+1), or 3·3 per cent, were parasitized, the highest parasitism being in *D. obscura*. Both sexes were infested. All stages of the nematodes have been found in the abdomens of the flies: gravid females (6 averaging 488 μ × 115 μ), eggs and young larvæ. As many as fourteen gravid females have been found within a single fly. Eelworm larvæ were sometimes especially abundant within the

Table 1

Date	*D. subobscura* ♂	*D. subobscura* ♀	*D. obscura* ♂	*D. obscura* ♀	*D. silvestris* ♂	*D. silvestris* ♀	Totals
Sept. 1953	—	2	5 (1)	10 (1)	18 (1)	13	48 (3)
Oct. 1953	5	12	12 (2)	24 (2)	23	21 (1)	97 (5)
Nov. 1953	1	69 (1)	—	5	—	—	75 (1)
Dec. 1953	—	59 (1)	—	2	—	—	61 (1)
Jan. 1954	—	37 (3)	—	3*(1)	—	—	40 (4)
Feb. 1954	13	15	—	—	—	—	28 (0)
Mar. 1954	—	88	—	3	—	—	91 (0)
April 1954	—	50 (1)	—	20 (2)	—	—	70 (3)
May 1954	—	6	—	25 (1)	—	—	31 (1)
(May 19, 1954)	(36 unidentified *obscura*-group (both sexes) dissected, only 1 (♀, *obscura*) with eelworms)						
Totals	19	338 (6)	17 (3)	92 (7)	41 (1)	34 (1)	

* Trapped in December but held over until January.

ovaries, which latter were then stunted and the eggs were not developing. This situation is presumably the start of larval migration from the host. In the four infested males, however, the testes appeared normal and larval eelworms were not observed within these organs.

The larval eelworms showed the beginnings of differentiation into males and females. By analogy with other species of nematode parasites of insects, it appears possible that the larvæ come to maturity in a free-living state, outside the host. Possibly, also, it is the larva of *Drosophila* that is infested by the entry of spermatized but immature female eelworms, which gradually develop during the metamorphosis of the fly. Another nematode, *Tylenchinema oscinellae* Goodey, during the winter months parasitizes the larva of the fritfly (*Oscinella frit* L.) and passes over into the adult fly which emerges in May[1]. It is not known, however, whether larvæ of the above three species of *Drosophila* survive the winter, though Basden (unpublished) finds that *D. silvestris* passes this period in a puparium.

There appear to be two other records of parasitism of *Drosophila* adults by nematodes. Van Zwaluwenburg[2] cites Crawford as having found the larvæ of *Habronema megastoma* (Rud., 1819) (Spiruridae) in an undetermined species of Drosophilid in Ceylon in 1926, and Gershenson[3] found that most individuals of *D. melanogaster* Mg. and all those of *Parascaptomyza disticha* (Duda) (Drosophilidae) caught near Kiev were infested with a species of *Chondronema* (Allantonematidae).

The investigation is being continued in greater detail. We are grateful to A. A. Spence for many of the dissections.

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A Method of isolating Vesicular Arbuscular Endophytes from Roots

The exact systematic position of the vesicular arbuscular endophytes has been a topic of some controversy. In 1900 Dangeard[1] proposed the genus *Rhizophagus* for these fungi, and considered that they were closely related to the Endogonaceae, but that they had lost the ability to form compound fructifications. Peyronel[2] also considered that these endophytes closely resembled *Endogone*.

Nicholls[3], working in this Department, made a preliminary study of the endophyte present in the roots of *Allium ursinum* and pointed out the morphological similarity of this organism to certain Oomycetous fungi. From portions of root, surface sterilized with a solution of sodium hypochlorite, washed and placed on plain agar, she frequently isolated a strain of *Pythium ultimum*. Owing to the sensitivity of this fungus to the hypochlorite solution, this isolation technique often failed, while less severe surface sterilization of the roots allowed common soil fungi, notably species of *Fusarium*, which were probably present as surface contaminants, to develop on the isolation plates to the exclusion of *Pythium*.

A more direct method of isolation of the endophyte has now been devised. Roots are thoroughly washed under the tap and then transferred to a flask of sterile water in which they are vigorously shaken for a few minutes. This process is repeated three more times, after which longitudinal sections of the roots are cut under aseptic conditions. The sections are then transferred to a sterile coverslip and covered with a few drops of plain agar which contains 0·2 ml. aureomycin per 15 ml. of medium. The coverslip is then sealed on to a glass ring as in the preparation of a hanging-drop chamber. The sections are examined daily until one of the intercellular hyphæ grows out from the cut edge. This hypha is then picked up and transferred to a plate of plain or malt agar.

The washing treatment is successful in removing most of the contaminating rhizosphere fungi, as roots treated in this way show only occasional growth of common soil organisms, and the position of these on the surface of the section can easily be seen. The addition of aureomycin to the agar inhibits the growth of any bacteria still adhering to the root.

By the use of this method, *P. ultimum* has again been isolated from infected roots of *Allium ursinum*.

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Nov. 12.

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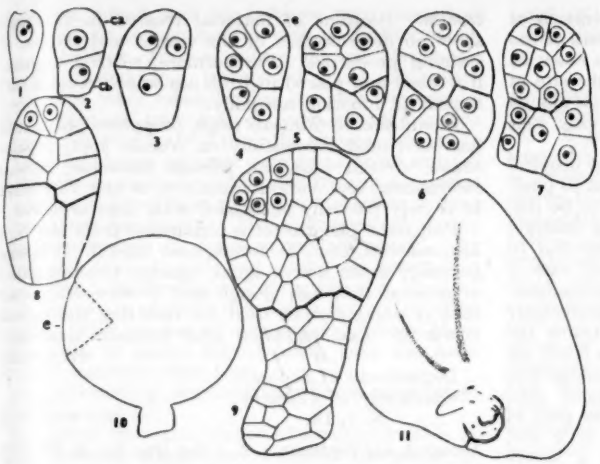
Embryo Development in Areca-nut

Embryo development in Palmae is unknown. There is only one description relating to the mature embryo of coconut, by Selvaratnam[1], who compared it with the embryo of Gramineae. The present communication describes the embryo development in *Areca catechu* L., commonly known as the areca-nut or betel-nut palm.

The first division in the fertilized egg (Fig. 1) is transverse and results in two cells *ca* and *cb* (Fig. 2). The latter divides first by a vertical wall and then in all planes. Its derivatives contribute to the formation of the suspensor, which becomes detached from the embryo proper in advanced stages. The terminal cell *ca* divides by an obliquely vertical wall resulting in two rather unequal cells (Fig. 3), the bigger of which undergoes a further division by a slanting wall. As a result, a triangular cell, the epiphyseal initial (Fig. 4 *e*), distinguishable from the rest by its shape and position, is formed. The derivatives of this cell give rise to the stem tip, while those of the sub-epiphyseal cells contribute to the formation of the cotyledon and the rest of the embryo proper. During the development of the embryo, there is a marked growth of the cotyledon on one side, resulting in the shifting of the position of the stem tip as shown in Figs. 5–10. As the embryo proper is exclusively derived from the products of *ca*, the embryo development in *Areca catechu* conforms to the onagrad type of Johansen[2]. So far the formation of an epiphysis in any monocotyledon showing the onagrad type is not known.



Figs. 1–11. Embryo development in *Areca catechu*
Figs. 1–8, × 300. Fig. 9, × 250. Fig. 10, × 120. Fig. 11, × 10

The fully developed embryo (Fig. 11) is conical and measures 4–4·5 mm. in length and 3–3·5 mm. in diameter at base. The single cotyledon completely encircles the plumule, leaving only a pore for its emergence during germination. The stem tip stands at an inclination of 170° to the long axis of the embryo and the root tip lies at 70° inclination to the stem tip. Both of them face the micropyle. The plumule shows several leaf primordia, each with some procambial strands. Vascular strands also extend nearly to the tip of the cotyledon from the procambial strands of the primary axis. The cells of the embryo are devoid of reserve food materials. The embryo is surrounded by copious ruminated endosperm in which hemicellulose and starch are stored.

I wish to thank the National Institute of Sciences of India for the award of a senior fellowship during the tenure of which this study was made; and also Prof. J. Venkateswarlu for his help and criticism.

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The Vector of an Outbreak of Kala-Azar in Kenya

It has recently been suggested that a new sandfly of termitaries, provisionally designated *Phlebotomus* (*Sergentomyia*) sp. nov. 2, may be the vector of an outbreak of kala-azar in Kenya Colony which has involved more than three thousand Africans[1]. Not only does the sandfly bite man, but also it is widely distributed throughout the epidemic area, and a small proportion are naturally infected with leptomonads in the anterior part of the mid-gut.

The purpose of this communication is to present further evidence incriminating this species. Previous attempts to infect specimens in the laboratory failed; but towards the end of December 1954, a few are believed to have become infected after being fed on the skin lesion of a patient with kala-azar. The lesion, first detected by Dr. P. E. Clinton Manson-Bahr (see following communication), was on the left shin of the patient and looked like a small healed tropical ulcer; it contained abundant *Leishmania*. Of seventy-five *P.* (*Ser.*) sp. nov. 2, fed in batches on the lesion, and dissected five to six days later, four, or approximately 5 per cent, contained leptomonads; three of the infections, all of which were scanty, had reached the anterior part of the mid-gut. Three of the positive sandflies were in a single batch of twenty-seven specimens, and if this batch had been the only one examined an infection-rate of 11 per cent would have been recorded. Five *P. clydei* (a sandfly of gerbil burrows regarded by Kirk and Lewis[2] as a possible vector in the Sudan) were also fed on the lesion but remained negative. During rather similar feeding experiments in the Sudan, the infection-rates for *P. orientalis* (believed to be the chief vector) and *P. clydei* were 7 and 1·8 per cent respectively, development also being of the anterior type[2]. It must be pointed out that the sandflies used in these experiments were 'wild-caught' specimens, and that some of the infections may have been previously acquired in Nature. The work should really be repeated using sandflies bred in the laboratory, but so far we have failed to rear *P.* (*Ser.*) sp. nov. 2 in captivity.

P. (*Ser.*) sp. nov. 2 has been shown to have a natural leptomonad infection-rate of only 1 per cent[1], the source of the leptomonads being uncertain. The sandflies used in the feeding experiments described in this communication were obtained from a termite hill in the kala-azar area, and ninety unfed specimens from the same site were negative on dissection. It therefore seems unlikely that the infections were previously acquired in Nature, although the possibility has not been entirely excluded.

It seems probable that *P.* (*Ser.*) sp. nov. 2 is the vector of the Kenya outbreak, though final proof is still lacking. The other anthropophilic species found in the kala-azar area occur in comparatively small numbers, and only bite man occasionally; none has yet been found infected with leptomonads in Nature.

I wish to thank the Director of Medical Services, Kenya, for permission to publish this communication.

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[1] Heisch, R. B., *Trans. Roy. Soc. Trop. Med. Hyg.*, **48**, 449 (1954).
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A Primary Skin Lesion in Visceral Leishmaniasis

Skin lesions containing Leishman–Donovan bodies in kala-azar have been recorded from the Sudan. Kirk and Sati[1], and Kirk[2], described a leishmanial skin lesion on the cheek which preceded visceral infection, and Petrov[3] claimed that, in Uzbekistan, kala-azar in children was preceded by skin ulcers.

Little is known about the method of penetration of the body by the *Leishmania* following the bite of the sandfly, and I would suggest that, in some cases at least, a primary skin lesion does occur at the site of the bite, with lymphatic spread to the regional glands and eventually to the viscera. The following case appears to support my hypothesis.

A male African (Mkamba) was admitted to hospital with a respiratory infection which responded to penicillin; when he felt well and was about to be discharged, a moderate generalized glandular enlargement was discovered which proved to be due to leishmaniasis. This was indeed a very early case of an otherwise symptomless and afebrile leishmaniasis. The axillary and groin glands were moderately enlarged. The spleen was palpable just below the left costal margin. The white cell count was 5,000 per c.mm., hæmoglobin 80 per cent and the formol–gel test slightly positive (solid opacity taking more than twenty minutes to develop). On the lower part of the left tibia was a skin lesion 3 cm. × 6 cm. with a central pink area, resembling a newly formed scar surrounded by a darker hyperpigmented zone. The central portion contained numerous *Leishmania*, and the outer darker area a few only. The left femoral gland was considerably enlarged and it, too, contained *Leishmania*. There were numerous parasites in the spleen, sternal marrow and glands. Blood culture was negative. A section of the lesion on the left tibia showed a central darker area just beneath the epidermis, which proved to be nests of intracellular *Leishmania* together with granulation tissue, large plasma cells, macrophages and newly formed blood vessels. The parasites were massed just beneath the epidermis. This distribution certainly suggests a primary initial leishmanial lesion at the site of the infective *Phlebotomus* bite, with regional glandular involvement and systemic spread.

In a recent series of nineteen untreated kala-azar cases two have shown similar lesions.

This observation is of importance as it suggests comparison with other protozoal diseases, such as trypanosomiasis (the trypanosome chancre).

I wish to thank the Director of Medical Services, Kenya, for permission to publish this communication.

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Use of Propylene Phenoxetol as a Relaxing Agent

Lamellibranchia are difficult to narcotize and then to fix without subsequent contraction of the tissues. It has been found that propylene phenoxetol can be used with considerable success to narcotize a variety of lamellibranchs. Using *Cardium edule*, the procedure was as follows: 5 c.c. of propylene phenoxetol was shaken vigorously with 15–20 c.c. of sea-water to produce a fine emulsion which was added to a breffit of sea-water containing actively siphoning specimens. Within half an hour the animals were completely relaxed with the foot protruding between the gaping shell valves and could be fixed in this condition without causing any contraction of the tissues. Sections of material treated in this way show no deterioration of the tissues and no loss of staining properties. Furthermore, relaxed animals, if washed and placed in fresh sea-water, recover and appear to function normally.

In addition to *Cardium edule*, propylene phenoxetol has been used successfully on *Nucula* spp., *Mytilus edulis*, *Arctica islandica*, *Glossus humanus*, *Spisula subtruncata*, and various members of the Veneridae. It is only partially successful with *Mya arenaria*.

Propylene phenoxetol is obtainable from the Nipa Laboratories, Ltd., Treforest, near Cardiff. It is used normally as an active agent against Gram-negative organisms, although Gough and Wentworth[1] found that it could also be used for restoring the natural colour to blood pigments after formalin fixation.

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Observations on a Human Tumour in Tissue Culture

In the course of studying 140 human tumours in tissue culture, a rapidly proliferating strain of cells was obtained from epidermoid carcinomatous tissue, part of which came directly from the patient (*H.*) (Jan. 21, 1953) and part from an animal (rat) implantation (Sept. 5, 1952) of cells from the tumour, a slowly growing epidermoid carcinoma of the larynx. The cultures have maintained for two years a consistent growth-pattern closely resembling morphologically the malignant tissue from the patient. The strain, being the first permanent one developed in the series, has been designated the *A* strain. During the first few months of propagation, conditioned medium was employed from cultures made from patients *K.* and *F.*, having epidermoid carcinomas of the neck and cervix respectively. Because of the possibility of the presence of rat cells in the strain, a study (carried out by Dr. J. J. Biesele, Sloan-Kettering Institute, New York) of the chromosomes was undertaken, after a year in tissue culture, which indicated that the cells were of human origin, having characteristic *V*- and *J*-shaped chromosomes.

During the past year, a substrain has developed which can withstand long periods of starvation. The cells which emerge after transferring cultures which have received no attention or renewal of medium for several months are long, thin, small and thread-like. After transferring and feeding for several months, the cells again show the typical epidermoid cancer morphology. These cells, after reversion, are called *Af* (*A* strain fibroblastic) cells. These cells survive freezing at − 20° C. During the transition period, the cells assume a form indistinguishable from normal fibroblasts, and the type of colony changes accordingly. Almost no lysis takes place.

The cultures from which the *Af* strain was derived were made (Gey's technique) on Aug. 10, 1953. Ten *A* cell cultures were taken from the Sloan-Kettering Institute in New York to the Tuberculosis Immunization Research Centre at the State Serum Institute in Copenhagen. During a two-month period the cultures remained at room temperature without the fluid phase. On Oct. 5, 1953, the cultures were removed with trypsin and transferred. The fluid

phase was added, and the cultures were rotated at 37° C. for one to two months with no further attention. On Nov. 12 one culture showed fibroblastic outgrowth and was transferred. As outgrowth occurred in other tubes, further transfers were made. The 'fibroblasts' grew actively, and several hundred subcultures were made during the ensuing months.

The fibroblastic cultures were transferred and fed in the routine manner, and gradually during a period of a few months reverted to the original strain pattern of epithelial carcinoma. The cells reverted during experiments done in January and February. By March and April the cells had completely reverted to type, after being dormant (looking like thin threads) or living as transitional fibroblasts for six to eight months. This process of converting dormant fibroblastic cells to active sheet-forming cells has been repeated regularly since then.

The 'hibernating' fibroblastic cultures accumulate large masses of fat.

The small, dormant, thread-like refractile cells in viable cultures which have received no media or attention for six to ten months might be considered a paramorphic type of cell, such as Hadfield[1] has discussed.

Apart from these fundamental observations, the cultures are of practical importance, as they constitute a large supply of stock material that requires no attention or media when not in use. The chance of losing the strain through accidental contamination is also lessened.

The fibroblastic cells appear to be resistant to agents that cause destruction of the epidermoid carcinomatous forms, such as the polio virus (Brunhilde strain obtained from Dr. Herdis von Magnus, State Serum Institute, Copenhagen) and chemical substances.

A more detailed report of the *A* and *Af* cells is in preparation.

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Biosynthesis of Hyaluronate

THE formation of hyaluronate by strains of Lancefield Group *A* and *C* streptococci growing in ordinary laboratory media was first shown by Kendall, Heidelberger and Dawson[1] and by Seastone[2]. More recently, it has been demonstrated[3] that the glucosamine and glucuronic acid moieties of hyaluronate are formed from glucose by cultures of these micro-organisms, without rearrangement of the carbon skeleton.

Previously we had reported[4] that glutamine specifically stimulates the formation of bound glucosamine, as hyaluronic acid, by washed preparations of group *A* streptococci incubated at 35° in a simple buffered glucose – salt solution of the following composition: 0·08 *M* sodium β glycerophosphate (anhydrous), 0·028 *M* glucose, 0·02 *M* magnesium chloride, 0·025 *M* inorganic phosphate buffer *p*H 7·0; the final *p*H of this mixture is 7·0. We now suggest, on the basis of further work using washed preparations, that the pathway for the synthesis of the glucosamine in hyaluronate by streptococci is:

(*a*) NH_4^+ + glutamic acid → glutamine;
(*b*) Glutamine + glucose (or hexose derivative) → bound glucosamine + glutamate.

Evidence for this suggestion is as follows. (1) Glutamine or ammonium glutamate stimulates the formation of bound hexosamine in aged preparations of washed cells, but neither ammonia nor glutamic acid is separately effective. (2) Methionine sulphoxide, known to inhibit glutamine synthesis from ammonium glutamate in other systems[5], prevents synthesis of bound glucosamine in the presence of ammonium glutamate but not in the presence of glutamine. (3) A close relationship exists between the amount of glutamine or ammonium glutamate taken up by the cells and the bound glucosamine formed; at lower levels of nitrogen source the amount of bound glucosamine–nitrogen appearing approximates to half the total nitrogen supplied. (4) A cell-free extract of streptococci supplemented by 10^{-3} *M* adenosine triphosphate, 0·022 *M* cysteine, 0·025 *M* inorganic phosphate, 0·028 *M* glucose and 0·02 *M* magnesium ion formed glucosamine from glutamine but not from ammonium glutamate; it is not known whether this hexosamine is free or bound into mucopolysaccharide. (5) Very high (80–100 per cent) conversion of nitrogen-15 from ammonium ion into bound glucosamine nitrogen of hyaluronate has been shown in the presence of unlabelled glutamate.

This work, together with the similar observations of Leloir and Cardini[6] for the formation of glucosamine by *Neurospora* extracts, suggests that the above pathway is a general one for the synthesis of hexosamine, at least in micro-organisms. Full details of this work will be published elsewhere.

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Utilization of Sulphate Ion by Fibroblasts in the Quartz Focus

MUCOPOLYSACCHARIDES are abundant in healing wounds and other sites where collagen is forming, and Meyer[1] postulated their production in large quantities by fibroblasts. The mast cell has been credited with producing 'ground substance'[2] or hyaluronic acid[3]; but Bunting and Bunting[4] recently reviewed much of the evidence for the source of mucopolysaccharide in fibroplasia and came to the conclusion that an origin from 'fibrocytes' seemed probable but not conclusive. Klemperer[5] expressed similar views: his objections were based largely on the non-specificity of the periodic acid – Schiff method for mucopolysaccharides. Gersh and Catchpole[6] had postulated previously a secretory cycle in

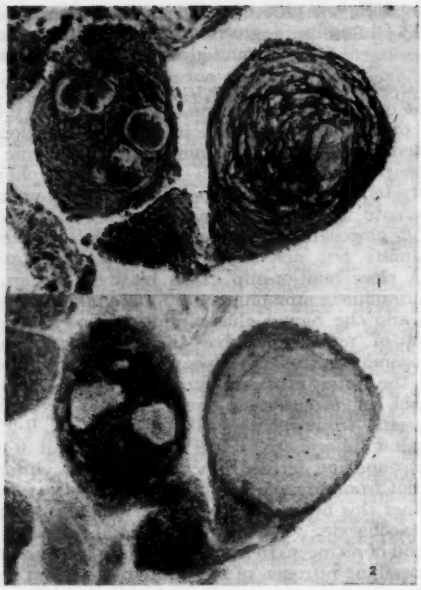

Fig. 1. Silicotic foci of 51 days duration in the omental tissues. The largest on the right consists mostly of dense collagen with fibroblasts at the periphery. The other two are still largely fibroblastic with only early formation of collagen fibres. Iron hæmatoxylin and Van Giesen. × 80

Fig. 2. Concentration of sulphur-35 is low in the mucopolysaccharide of the collagenous focus. It is high in the fibroblasts at the periphery of this focus and in those of the cellular foci. Autoradiograph. × 80

fibroblasts dependent on the specificity of this technique.

Mucopolysaccharides are present in developing quartz foci, in the cytoplasm of fibroblasts and in unphagocyted dust[7]. The large cells which invade and phagocytose the dust are stimulated to intense collagen production. There is stainable mucopolysaccharide in their cytoplasm, and some is liberated into the focus.

In autoradiographs, sulphur-35, given as sulphate ion, is 'fixed' only in the sulphated mucopolysaccharides of the tissues and is present in particularly high concentration within the cytoplasm of cells producing these. Mammals are unable to incorporate the $^{35}SO_4$ ion into the sulphur-containing amino-acids, and the trace of sulphur-35 found in cystine is almost certainly formed by the animal's intestinal micro-organisms. In this way the autoradiographic method determines accurately only those cells which elaborate mucopolysaccharide.

Silicotic foci were produced in the peritoneal tissues of albino mice by the methods already described[7] and lesions of ages from 9 to 120 days were studied. Sulphur-35 was administered as sulphate ion at *p*H 7 and autoradiographs prepared[8].

Sulphur-35 was taken up and retained within the developing quartz foci. Invariably the element was in high concentration only in the cellular fibroblastic zones (Figs. 1 and 2). Where fibroblasts were widely dispersed, localization of the ion could be confirmed within their cytoplasm. Only low concentrations of sulphur-35 were present in the extracellular mucopolysaccharide, particularly when this was accompanied by abundant collagen fibres. Testicular hyaluronidase (Benger's 'Hyalase') had no effect on the distribution of the radioactive ion. In view of the specific nature of the location of the $^{35}SO_4$ ion within the cytoplasm of cells forming mucopolysaccharide[8], the evidence presented here strengthens greatly the belief that fibroblasts do form and secrete mucopolysaccharides into the surrounding tissues during collagen formation.

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Glasgow.
Nov. 8.

[1] Meyer, K., *Physiol. Rev.*, **27**, 335 (1947).
[2] Sylvén, B., *Acta chir. Scand.*, **86**, Supp. 66, 1 (1941).
[3] Asboe-Hansen, G., *Cancer Res.*, **13**, 587 (1953).
[4] Bunting, C. H., and Bunting, H., *Arch. Path.*, **55**, 257 (1953).
[5] Klemperer, P., *Amer. J. Path.*, **26**, 505 (1950); *Bull. New York Acad. Med.*, **28**, 204 (1952).
[6] Gersh, I., and Catchpole, H. R., *Amer. J. Anat.*, **85**, 457 (1949).
[7] Curran, R. C., *Brit. J. Exp. Path.*, **33**, 82 (1952); *J. Path. Bact.*, **66**, (1), 271 (1953).
[8] Curran, R. C., and Kennedy, J. S., *J. Path. Bact.* (in the press).

"Animal Cytology and Evolution"

We were surprised at the content, and still more at the tone, of the review by Prof. C. D. Darlington of M. J. D. White's "Animal Cytology and Evolution"[1]. In our opinion, it would be unfortunate if the many criticisms given under the authority of Darlington's name were allowed to obscure what seem to us the merits of this book. White's book contains not only a most useful and critical compilation of scattered data, but also many stimulating discussions of a variety of topics; and it is a valuable part of Dr. White's work that he makes it clear which of his remarks are intended to be factual and which theoretical.

C. H. Waddington

Institute of Animal Genetics,
Edinburgh.

H. G. Callan

Department of Natural History,
St. Andrew's.
Feb. 7.

[1] "Genetics and the Chromosomes", *Nature*, **175**, 4 (1955).

"Independence in Publication"

The subject of Prof. A. V. Hill's communication[1] is one of long standing.

Prof. Elliott Coues published a "Handbook of Field and General Ornithology" in 1890[2] in which he gives instructions for the collection of specimens. He lists all the details that should be recorded on labels, including: "Name of the person in charge of the [survey, voyage, exploration, or other expedition (if any), during which the specimen was collected] (and it may be remarked that the less he really cares about birds, and the less he actually interests himself to procure them, the more particular he will be about this)."

L. Harrison Matthews

Zoological Society of London,
Regent's Park,
London, N.W.1.
Feb. 10.

[1] *Nature*, **175**, 266 (1955).
[2] Coues, E., "Handbook of Field and General Ornithology" (Macmillan, London, 1890).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 7

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. W. E. Ripper: "Spraying of Crops by Helicopter".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. J. Wright: "Utilization of Fission Product Radiation".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the Woolwich Polytechnic Scientific Society, at the Woolwich Polytechnic, London, S.E.18), at 7.30 p.m.—Mr. L. C. Nickolls: "Some Chemical Aspects of Forensic Science".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. Merlin Minshall: "Sailing Across Europe".

Tuesday, March 8

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Mr. J. W. McPherson: "Some Non-Linear Magnetic Devices and their Application to Telecommunications".

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Mr. D. R. R. Dick: "The Civil Engineer and Britain's Atomic Factories".

UNIVERSITY OF LONDON (in the Meyerstein Lecture Theatre, Westminster Medical School, Horseferry Road, London, S.W.1), at 5.30 p.m.—Academician W. A. Engelhardt (U.S.S.R.): "Mechano-Chemistry of Muscle".* (Further lecture on March 16.)

INSTITUTION OF THE RUBBER INDUSTRY, LONDON SECTION (joint meeting with the PLASTICS INSTITUTE, at the "Oversea" League, Park Place, St. James's, London, S.W.1), at 7 p.m.—Dr. A. Charlesby: "Changes in Rubber-like Materials by Exposure to High Energy Radiation".

Wednesday, March 9

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. L. Grunberg: "The Viscosity of Liquid Hydrocarbons".*

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. P. E. Axon, Mr. C. L. S. Gilford and Mr. D. E. L. Shorter: "Artificial Reverberation".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. T. M. Sonneborn (University of Indiana): "Paramecium in Modern Biology".* (Further lectures on March 10 and 11.)

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. C. R. Skoglund (Stockholm): "The Functional Organization of Spinal Interneurones".* (Further lecture on March 11.)

ILLUMINATING ENGINEERING SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Sir Harold Spencer Jones, F.R.S.: "The Brightness of the Stars". (Third Trotter-Paterson Memorial Lecture.)

UNIVERSITY OF LONDON (in the Beveridge Hall, Senate House, London, W.C.1), at 6 p.m.—Sir Henry Tizard, F.R.S.: "A Scientist In and Out of the Civil Service".* (Haldane Memorial Lecture.)

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. E. C. Barton-Wright: "The Problem of Protein Haze in Bottled Beer"; Dr. E. H. Callow: "Factors Affecting the Water Content of Meat".

Thursday, March 10

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP, NORTHERN BRANCH (at the University, Nottingham), at 4.30 p.m.—Dr. J. O. Wisdom: "Is the Philosophy of Science a Science?"

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (in the Science Museum Lecture Theatre, Exhibition Road, London, S.W.7), at 4.30 p.m.—Dr. G. G. Haselden: "Some Experimental Problems Encountered in the Fractionation of Liquid Air".

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr. W. Gumz: "Fuel Developments in Germany".*

ROYAL METEOROLOGICAL SOCIETY (in the Conference Hall, County Hall, Westminster Bridge, London, S.E.1), at 5.30 p.m.—Mr. F. Ludlam: "Clouds".* (Meeting open to Sixth-form Scholars.)

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. P. M. S. Blackett, F.R.S.: "War and Scientific Development".* (Last of a series of lectures on "War and Society".)

UNIVERSITY OF LONDON (at Senate House, London, W.C.1), at 5.30 p.m.—Dr. P. Karrer (University of Zurich): "Curare-Alkaloids".* (Further lecture on March 11.)

INSTITUTION OF MECHANICAL ENGINEERS, INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "The Engineer as an Administrator".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the WEST HAM COLLEGE OF TECHNOLOGY CHEMICAL SOCIETY, at the West Ham College of Technology, Romford Road, London, E.15), at 7 p.m.—Prof. H. J. Emeléus, F.R.S.: "Fluorine".

Friday, March 11

BEDSON CLUB (in Lecture Theatre I, New Chemistry Building, King's College, Newcastle upon Tyne 1), at 5.30 p.m.—Prof. F. J. W. Roughton, F.R.S.: "Rapid Reactions of Hæmoglobin with Oxygen and Carbon Monoxide". (99th Bedson Lecture.)

SOUTH PLACE ETHICAL SOCIETY (at Conway Hall, Red Lion Square, London, W.C.1), at 7.30 p.m.—Lord Boyd-Orr, F.R.S.: "Ethics in the Atomic Age" (Conway Memorial Lecture).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Arnold A. Hall, F.R.S.: "Experimental Techniques Used in Aeronautical Research and Development".

Saturday, March 12

NUTRITION SOCIETY (at St. Mary's Hospital Medical School, London, W.2), at 10.45 a.m.—Symposium on "Alcohol and its Nutritional Significance".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (with a good honours degree or Associate of the Royal Institute of Chemistry, and with research and/or industrial experience) IN CHEMISTRY, and a LECTURER (with a good honours degree or Associate of the Institute of Physics, and with research and/or industrial experience) IN PHYSICS, at the Technical College of Monmouthshire, Crumlin, Newport—The Director of Education, County Hall, Newport, Mon. (March 12).

SENIOR RESEARCH OFFICER (with a degree in agricultural science or science of an Australian university, or of an overseas university of equivalent standing; or equivalent qualifications which should include a university degree supported by special postgraduate experience in research and/or teaching in plant pathology), IN THE PLANT QUARANTINE SECTION, Department of Health, Canberra, for research and investigation into matters affecting plant quarantine involving liaison and co-operation with appropriate institutions and technical workers in Australia—Chief Commonwealth Medical Officer, Australia House, Strand, London, W.C.2 (March 19).

ASSISTANT EXPERIMENTAL OFFICER (male) (graduate in botany or agricultural botany, with training in plant physiology and preferably some knowledge of modern methods of field experimentation), IN THE BOTANY DEPARTMENT to help in field work on the physiological analysis of growth and yield of agricultural crops, and in related laboratory work—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting "102" (March 21).

CHAIR OF ZOOLOGY at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (March 21).

LECTURER (with a good honours degree or equivalent qualification in mechanical engineering, and with practical experience in industry and in teaching) IN MECHANICAL ENGINEERING—The Principal, Wigan and District Mining and Technical College, Wigan (March 21).

SENIOR LECTURER or LECTURER IN PHYSIOLOGY at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (March 21).

RESEARCH ASSISTANT (preferably with an honours degree in medical sciences or biology, and a knowledge of German) IN THE DEPARTMENT OF ANATOMY, for work mainly on the central nervous system—The Secretary, University College, Gower Street, London, W.C.1 (March 26).

RESEARCH ASSISTANT (with a first- or good second-class degree in botany, with ecological and physiological interests) IN ECOLOGY—The Secretary and Registrar, The University, Southampton (March 26).

RESEARCH OFFICER (with an honours degree in engineering or science or equivalent qualifications) IN THE DIVISION OF BUILDING RESEARCH, Commonwealth Scientific and Industrial Research Organization, Highett, Victoria, Australia, to participate in a programme of theoretical and experimental research on the properties and uses of lightweight concrete and gypsum plaster as structural materials—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 390/209 (March 26).

ASSISTANT LECTURER (preferably with interests in applied mathematics) IN THE DEPARTMENT OF MATHEMATICS—The Secretary, University College London, Gower Street, London, W.C.1 (March 28).

LECTURER IN REFRACTORY MATERIALS IN THE DEPARTMENT OF METALLURGY—The Registrar, The University, Sheffield (March 31).

SENIOR LECTURER IN ELECTRICAL ENGINEERING at the University, Adelaide, South Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Adelaide, March 31).

SCIENTIFIC OFFICER (with a first- or second-class honours degree in an approved scientific subject or other approved equivalent qualification) IN THE DEPARTMENT OF INDUSTRIAL AND FORENSIC SCIENCE of the Ministry of Commerce—The Secretary, Civil Service Commission, Stormont, Belfast (April 1).

UNIVERSITY DEMONSTRATOR (with an honours degree in some branch of natural science, and preferably with a veterinary qualification and experience in teaching the subject) IN VETERINARY ANATOMY—Dr. A. S. Watt, Botany Department, Downing Street, Cambridge (April 1).

CHAIR OF APPLIED MATHEMATICS—The Registrar, The University, Sheffield 10 (April 2).

RESEARCH FELLOWS, for independent research—The Registrar, The University, Reading (April 12).

READER or SENIOR LECTURER IN APPLIED MATHEMATICS at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Hong Kong, April 15).

I.C.I. RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, CHEMOTHERAPY, ENGINEERING, METALLURGY, PHARMACOLOGY, PHYSICS or allied subjects—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 16).

TURNER AND NEWALL RESEARCH FELLOWS IN ENGINEERING, INORGANIC CHEMISTRY, PHYSICS or an allied subject—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 16).

ASSISTANT LECTURER (honours graduate in botany or agricultural botany) IN AGRICULTURAL BOTANY—The Registrar, The University, Reading (April 30).

RESEARCH ASSISTANT (with a medical degree or an honours degree in physiology or zoology) IN THE CLIMATIC AND WORKING EFFICIENCY UNIT of the Medical Research Council, Department of Human Anatomy, University of Oxford, to take part in fundamental studies of muscle and joint action and the application of this to clinical, industrial and service problems—Prof. Sir Wilfrid Le Gros Clark, F.R.S., Department of Human Anatomy, University Museum, Oxford (April 30).

RESEARCH FELLOW IN THE DEPARTMENT OF CHEMISTRY for work on heterogeneous catalysis—Prof. C. Kemball, Queen's University, Belfast (April 30).

ASSISTANT PROFESSOR OF SOIL SCIENCE—Head of the Department of Soil Science, Faculty of Agriculture, University of Alberta, Edmonton, Alberta, Canada (May 1).

ASSISTANT LECTURER, Grade B (with a good honours degree in physics or electrical engineering, and with some research, industrial or teaching experience) IN THE DEPARTMENT OF APPLIED PHYSICS, College of Technology and Commerce, Cardiff—The Director of Education, City Hall, Cardiff.

CHEMIST or BIOLOGIST (with at least a second-class honours degree in chemistry or biology, and a good knowledge of chemical analysis) IN THE HEALTH PHYSICS DIVISION, to undertake work on the uptake and metabolism of radioactive elements in biological materials—The Establishments Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/237.

FISHERIES OFFICER (with a university degree in natural science, preferably zoology) in the Lake Victoria Fisheries Service, East Africa High Commission, for duties which include the development and control of the fisheries of Lake Victoria—Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.65/88/01.

LECTURER, Grade B (graduate of a British university with chemistry as one of the major subjects, and preferably with a knowledge of nutrition or hygiene), to teach Science as applied to Catering and allied subjects—Clerk to the Governing Body, Battersea Polytechnic, London, S.W.11.

RESEARCH ENGINEER (about 27 years, with an honours degree in engineering and one or two years practical experience) IN THE RESEARCH AND DEVELOPMENT DIVISION of the Cement and Concrete Association, near Slough, to work on concrete materials and methods of construction—The Secretary, Cement and Concrete Association, 52 Grosvenor Gardens, London, S.W.1.

SENIOR SOIL CONSERVATION OFFICER (with a university degree in an appropriate subject, and at least one years postgraduate study or experience of soil conservation) IN THE DEPARTMENT OF AGRICULTURE, Gold Coast Local Civil Service, for duties which comprise the planning, administration and execution of schemes for soil conservation and land utilization, and the tendering of advice on problems of soil conservation—The Director of Recruitment, Colonial Office, 2 Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.63/13/017.

SOIL SURVEY OFFICER (with a degree either in geography, or in science with geology or geography as one subject) IN THE DEPARTMENT OF AGRICULTURE, Western Region, Nigeria, to take part in the field work of a scheme of systematic classification and mapping of soils—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.63/410/02.

REPORTS and other PUBLICATIONS

(not included in the Monthly Books Supplement)

Great Britain and Ireland

London and Home Counties Regional Advisory Council for Higher Technological Education. Bulletin of Special Courses in Higher Technology (including Management Studies and Commerce), 1954–55. Part 2: Spring and Summer Terms, 1955. Pp. v+41. (London: London and Home Counties Regional Advisory Council for Higher Technological Education, 1954.) 1s. 6d. [1712

British Gelatine and Glue Research Association. Sixth Annual Report for the year October 1953 to September 1954. Pp. 15. (London: British Gelatine and Glue Research Association, 1954.) [1712

Royal Entomological Society of London. Handbooks for the Identification of British Insects. Vol. 4, Part 8 (a): Coleoptera—Staphylinidae. Section (a): Piestinae to Euaesthetinae. By the Rev. C. E. Tottenham. Pp. 79. (London: Royal Entomological Society of London, 1954.) 15s. [1712

The Nuffield Foundation. Report for the year ended 31 March 1954. Pp. 141. Report on grants made during the ten years April 1943 to March 1953. Pp. 319. (London: The Nuffield Foundation, 1954.) [2112

Royal Institute of Chemistry. Lectures, Monographs and Reports 1954. No. 6: A Physical Approach to Terpenoid Strictures. By Prof. J. Monteath Robertson. (Third Henderson Memorial Lecture.) Pp. ii+21. (London: Royal Institute of Chemistry, 1954.) [2112

Anti-Locust Research Centre. Anti-Locust Bulletin No. 18: Sexual Maturation in the Desert Locust (*Schistocerca gregaria* Forskål), with special reference to the Effects of Grouping. By Dr. Maud J. Norris. Pp. ii+46. (London: Anti-Locust Research Centre, c/o British Museum (Natural History), 1954.) 4s. 6d. [2112

Ministry of Fuel and Power. Safety in Mines Research Establishment. Thirty-second Annual Report on Safety in Mines Research, 1953. Pp. 83+4 plates. (London: H.M. Stationery Office, 1954.) 3s. net. [2112

Other Countries

Geological Map of East Africa. (Dar-es-Salaam: Department of Lands and Surveys, 1954.) [1512

U.S. Department of Commerce—National Bureau of Standards. N.B.S. Circular 549: Computation of Achromatic Objectives. By Robert E. Stephens. Pp. 7. (Washington, D.C.: Government Printing Office, 1954.) 10 cents. [1512

New York University—College of Engineering. Meteorological Papers. Vol. 2, No. 3 (June 1954): The Atmospheric Lunar Tides. By Ryukichi Sawada. Pp. 31. (New York: New York University Press, 1954.) 1.50 dollars. [1512

Birds the World Over. By Austin L. Rand and Emmet R. Blake. Pp. 97. (Chicago Natural History Museum, 1954.) 1.50 dollars. [1512

Reports of the Biochemical Research Foundation of the Franklin Institute. Vol. 12: 1952–1953; with an Index to B.R.F. Publications Nos. 1 to 263, and B.R.F. Notes, Nov. 1938 to Dec. 1953; Bound in Reports from the Biochemical Research Foundation, Volumes 1 to 12, 1930–1953. Pp. 154. (Newark, Delaware: Biochemical Research Foundation of the Franklin Institute, 1954.) [1512

Canada—Department of Mines and Technical Surveys. Map of Canada: Principal Mining Areas and Producing Mines. (Map 900A. Fourth edition.) (Ottawa: Queen's Printer, 1954.) [1512

Southern Rhodesia. Geological Survey Bulletin No. 41: The Geology of the Country between Concession and Msonneddi (Mazoe District). By J. G. Stagman. Pp. vii+48+4 plates. (Salisbury: Government Printer, 1953.) [1512

Publications de l'Institut National Turc de Bibliographie. Bibliographie des Articles Parus dans les Periodiques Turcs, 1953. (4–6—Avril–Juin.) Pp. 13. (Istanbul: Maarif Basimevi, 1954.) [1512

Metropolitan Life Insurance Company, Statistical Bulletin, Vol. 35, No. 10: Chances of Death in a Family. Pp. 12. (New York: Metropolitan Life Insurance Company, 1954.) [1512

U.S. Department of Agriculture. Leaflet No. 368: The Alfalfa Weevil: How to Control It. Pp. 8. (Washington, D.C.: Government Printing Office, 1954.) 5 cents. [1512

Tanganyika. Geological Survey Department. Bulletin No. 25: The Geology of the Galula Coalfield, Mbeya District. By J. Spence. Pp. iv+35. (Dar-es-Salaam: Government Printer, 1954.) 8 shs. [1512

Canada: Defence Research Board. The Earth's Exterior Atmosphere and the Counterglow: The Counterglow as Related to Modern Geophysical Theories, with seven recent Russian papers collected and translated by E. R. Hope. Second edition. Pp. xxviii+52. (T 65 R, Ottawa: Defence Research Board (Defence Scientific Information Service), 1954.) [1512

Centre National de la Recherche Scientifique. Le Laboratoire Sous-terrain: du Centre National de la Recherche Scientifique a Moulis (Ariège). Pp. 24. Centre d'Études de Chimie Métallurgique, Vitry-sur-Seine (Seine). Pp. 70. (Paris: Centre National de la Recherche Scientifique, 1954.) [1512

Meddelande Från Lunds Astronomiska Observatorium.. Ser. 1, Nr. 187: Metagalactic Distance Indicators and Spatial Distribution of Galaxies. By Knut Lundmark. Pp. 195–210. (Lund: Hakan Ohlsson Boktryckeri, 1954.) [1512

Arkiv för Astronomi. Utgivet av Kungl. Svenska Vetenskaps-akademien, Band 1, Nr. 35: On the Resolving Power of the Photographic Image with Special Regard to the Developer. By Nils Hansson. (Meddelande Fran Lunds Observatorium, Ser. 1, Nr. 182.) Pp. 12. (Stockholm: Almqvist and Wiksells Boktryckeri; London: H. K. Lewis and Co., Ltd., 1954.) [1512

Commonwealth of Australia. Commonwealth Scientific and Industrial Research Organization. Sixth Annual Report for the year ending 30th June 1954 (1953–54). Pp. vi+372. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1954.) [1512

Bulletin of the Astronomical Institutes of the Netherlands. Vol. 12: No. 456 (1954, November 22): The Acceleration of Interstellar Clouds. By F. D. Kahn. Pp. 187–200. Vol. 12, No. 457 (1954, November 30): The Dependence of Interstellar Absorption of Light on the Wavelength. By J. Borgman. Pp. 201–210. Vol. 12, No. 458 (1954, December 1): The Rotation of the Inner Parts of the Galactic System. By K. K. Kwee, C. A. Muller and G. Westerhout. Pp. 211–222. (Leiden: Astronomical Institutes of the Netherlands, 1954.) [1712

New Zealand Meteorological Service. Meteorological Office Note No. 40: The Drift of Radioactive Dust from the British Nuclear Bomb Tests in October 1953. By J. F. Gabites. Pp. 7. (Wellington: Meteorological Office, 1954.) [1712

Pontificia Academia Scientiarum. Acta. Vol. 15. No. 1: Sulle Condizioni di Validita della Formula di Green-Stokes Generale. Di Giulio Aruffo. Pp. 14. No. 2: Questioni Analitiche Inerenti ai Problemi di Stabilita dell' Equilibrio Elastico. Di Luigi Broglio. No. 3: Notizie sul Gesuita Cristoforo Borri e su sue "Inventioni" da Carte Finora Sconosciute di Poetro della Valle II Pellegrino. Di Angelo Mercati. Pp. 25–46. No. 4: Osservazioni Critiche Circa l'Efficacia Dimostrativa dell' Esperimento di Kennedy. Di Mario Galli. Pp. 47–56. No. 5: Il Fisico Tedesco Giorgio Mattia Bose e Benedetto 14. Di Angelo Mercati. Pp. 57–70. No. 6: Ein Vorschlag zur Empirischen Reduktion von Spektralverteilungen. Von Joseph Junkes, S.J. Pp. 73–76. No. 7: Eduazioni Integrali a Nuclei Sommabili. Di Giulio Platone. Pp. 77–92. No. 8: Un Metodo di Interpretazione Analitica di una Batteria di Reattivi. Di Marcello Cesa-Bianchi e Angelo Perugia. Pp. 93–104. No. 9: Richerche sul Comportamento degli Interessi nell' età Evolutiva. Di Angelo Perugia. Pp. 105–120. No. 10: Proprieta della Strutture Elastoplastiche nello Spazio delle Iperstatiche. Di Leo Finzi. Pp. 121–136. No. 11: Dimostrazione Intrinseca del Teorema di Ruemann-Roch Sopra una Curva. Di Edoardo Vesentini. Pp. 137–152. (Città del Vaticano: Pontificia Academia Scientiarum, 1951–1953.) [1712